POWER

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The Momentum of a Power Station

IT DOES not hurt a man to fall a thousand feet or so.

It is the stopping that hurts.

A great hydro-electric station is humming along under full load, a river of water coming down the penstock at the velocity due to its drop from a high head. Suddenly the load is lost. The gates close, and if it were not for the surge tank provided to allow the water to mount freely to such an elevation that the work performed in its lifting would absorb the momentum of the swiftly moving mass, the works would be ruptured by the pressure that would be generated.

What takes care of all this momentum in a stream-driven plant?

A plant that is developing 100,000 horsepower is turning out energy at a rate equal to that produced by a weight of 275 tons falling at the rate of 100 feet per second.

It would make something of a shock to stop that suddenly, would it not?

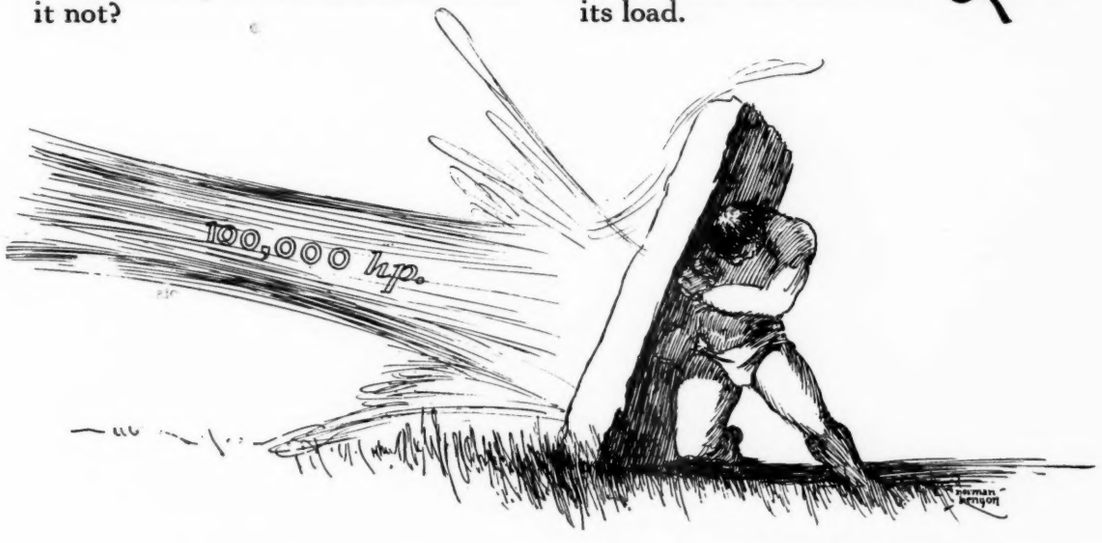
Its energy would be equivalent to that in a stream of water about 8.5 feet in diameter spouting at a velocity of 100 feet per second. A mile a minute is only 88 feet per second. Would it mean something to stop this instantly?

Steam of 1,200 pounds pressure weighs nearly 3 pounds per cubic foot. Will it mean anything to stop instantly a column of such steam flowing at the rate of a couple of miles a minute?

A transmission line may be transmitting 100,000 horsepower and something happens that causes the switch to open and bring this flow of energy to rest in a small fraction of a second. Five switches designed for such a system would have a total rupturing capacity about equivalent to the power of Niagara Falls.

Something more happens than the blowing of the safety valves when a 100,000 horsepower station loses its load.

F. R. Low



Fitting the Electric Motor to the Pump

Effects of Pipe Sizes on the Cost of Pumping—Effect of Methods of Controlling Pump Output on Motor Power Consumption—Pump Characteristics—Choice of Motor and Control Equipment.

By R. H. ROGERS
Engineer, Power and Mining Engineering Department, General Electric Company

PUMPING is a fundamental operation in all industrial plants which lends itself admirably to electric drive. The selection of pumps, motors and control for the most successful operation under all conditions and circumstances is not a simple problem, and if not well studied out the plant is penalized continuously through the following years. The fact that some of the major industries with well-organized engineering departments are operating many pumps with characteristics entirely unfitted for the service would indicate

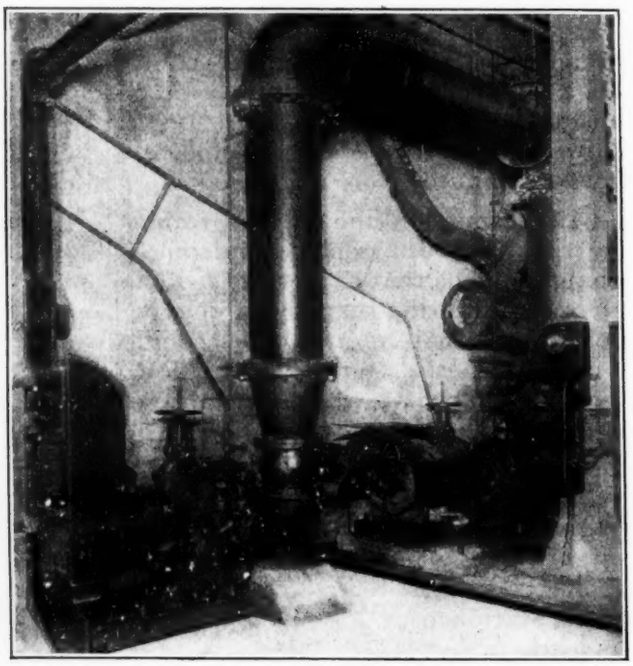


FIG. 1—SULPHITE STOCK PUMPS IN A PAPER MILL INSTALLED TO TAKE FULL ADVANTAGE OF THE FLEXIBILITY OF MOTOR DRIVE WHICH ALLOWS OF PUMPS BEING LOCATED IN THE DIRECT LINE BETWEEN LEVELS

that this branch of engineering needs some explaining, especially for those who have little time for an intensive study of these problems.

The clearest way to show all the elements that effect the over-all efficiency of electric pumping units is to analyze the whole span from the electric meter to the work accomplished, not overlooking other items that make an installation successful. The items that directly affect the kilowatt-hours per million gallon feet are:

Ratio of Dynamic Head to Static Head—The vertical measurement from level to level, or the calculated head if pumping against say boiler pressure, is not the measure of the pump's work. Every foot of pipe, every valve, every elbow or other fitting adds to the theoretical to make the actual or dynamic head.

For instance, considering only pipe diameter, a 5-in. three-stage centrifugal pump delivering 300 gal. per min. through 300 ft. of 5-in. pipe will cost $375 per year more to operate than if a 10-in. pipe were used on a basis of power costing 2c. per kilowatt-hour. This differential would pay for the larger pipe in a year. Tables of heads to be added for sizes of pipes, valves, elbows, etc., at various velocities are available in pump catalogs and handbooks, and they deserve close consideration. In general the piping should have much greater area than the pump openings, as high velocity is essential in the pump but is detrimental in piping. Six to eight feet per second should not be exceeded, and less is desirable, since once installed, the loss goes on for years.

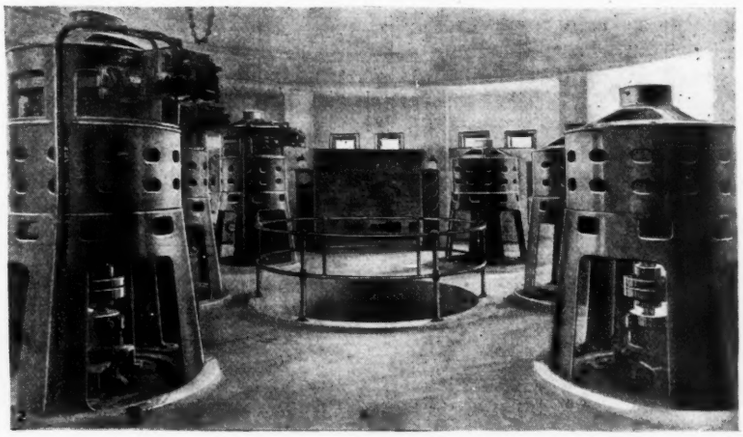
The suction pipe should be deeply immersed, should be as short as is practical consistent with good installation practice and the bends, if any, should be of long radius. An excess of dynamic head over static head means just that much more work for the motor, and if it is 10 per cent or 50 per cent that excess will show up at the power meter.

Fig. 1 shows pump installations with no suction lift as they are placed alongside the sulphite stock tank. The piping is liberal in size so that the difference between dynamic and static head is slight.

Pump Characteristics—Head, gallons per minute, efficiency, revolutions per minute and horsepower plotted together show the character of a centrifugal pump. If the speed at the point of best efficiency is at or near an induction-motor speed, namely, 1,730, 1,150, 865, 690 or 575, it will insure its operation at the most efficient point if direct connected to a squirrel-cage induction motor.

If the horsepower required at the most efficient point is near one of the standard squirrel-cage motor ratings —that is, 200, 150, 125, 100, 75, 60, 50, 40, 30, 25 hp. etc.—it will insure a high over-all efficiency for the set. Fortunately, induction motors have a flat efficiency curve through the working range, such as 90 per cent at full load, 90.5 per cent at 75 per cent load and 90 per cent at 50 per cent load, so that this feature has little effect. However, the power factors of such motors require that they be operated at near full load to keep the current to a minimum. Power factor affects only the distribution, transforming and generating system and not the meter, except as the rates may be adjusted to penalize low power factor in a plant. At loads as given in the foregoing, the power factor may be in the order of 89, 87 and 80 per cent respectively.

A desirable characteristic in centrifugal pumps is that of having the load fall off each way from the best operating point. This prevents an overload coming on the motor by an accident or mishandling of valves which would subject it to a maximum head (closed off) or minimum head (direct discharge).



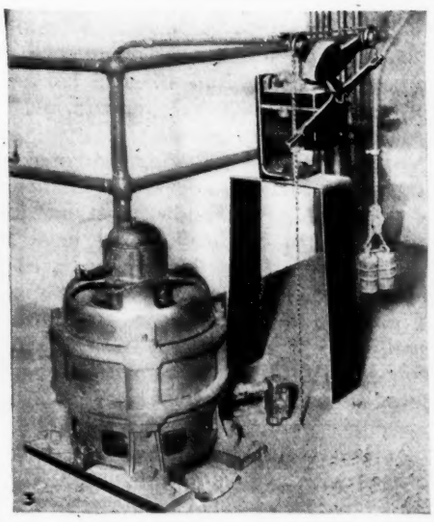
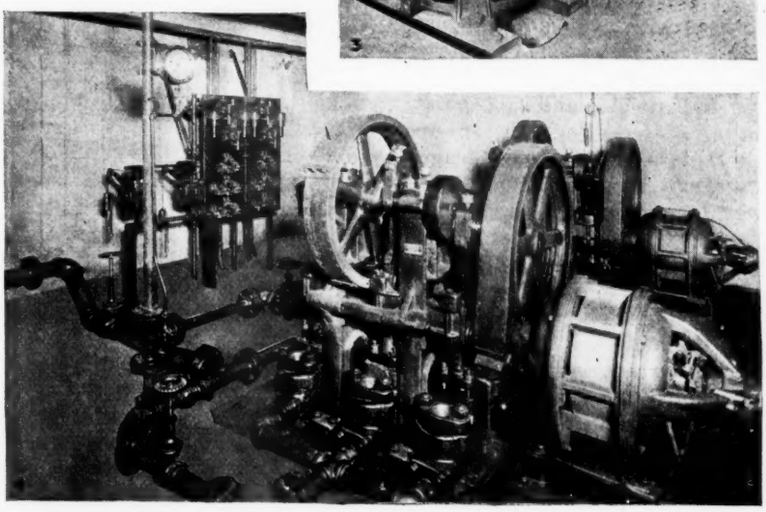


FIG. 2—MOTORS AT RIGHT ARE BRUSH-SHIFTING TYPE WITH PILOT-MOTOR CONTROL; MOTORS AT LEFT ARE OF SQUIRREL-CAGE TYPE. ALL DRIVING CENTRIFUGAL PUMPS. FIG. 3—VERTICAL 15-HP. SQUIRREL-CAGE SUMP-PUMP MOTOR WITH FLOAT-SWITCH CONTROL. FIG. 4—RECIPROCATING PUMPS REQUIRE THE HIGH STARTING TORQUE OF WOUND ROTOR MOTORS. FLOAT-SWITCH CONTROL AT LEFT



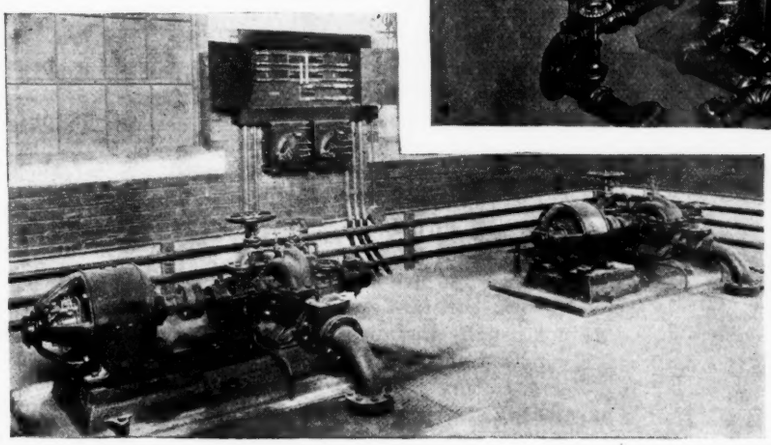
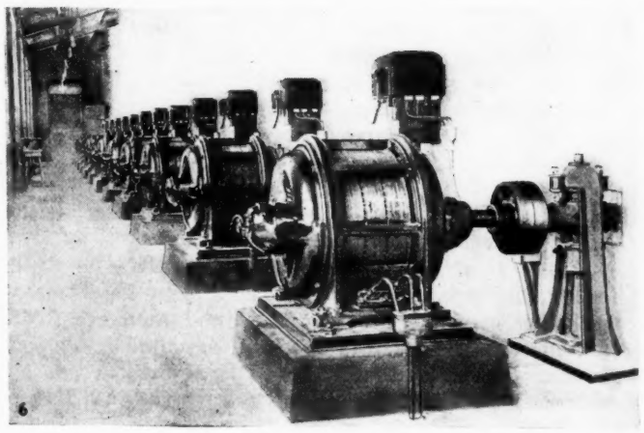


FIG. 5—COMPOUND-WOUND MOTORS DRIVING PUMPS IN A NITRATE PLANT. FIG. 6—BATTERY OF SQUIRREL-CAGE MOTORS WITH OIL-SWITCH STARTERS DRIVING GASOLINE PUMPS. AS THERE ARE NO EXPOSED CONTACTS, THERE IS NO DANGER OF CAUSING A FIRE OR EXPLOSION. FIG. 7—A 40-HP. SQUIRREL-CAGE MOTOR DRIVING AN ACID PUMP AND EXPOSED TO ACID FUMES



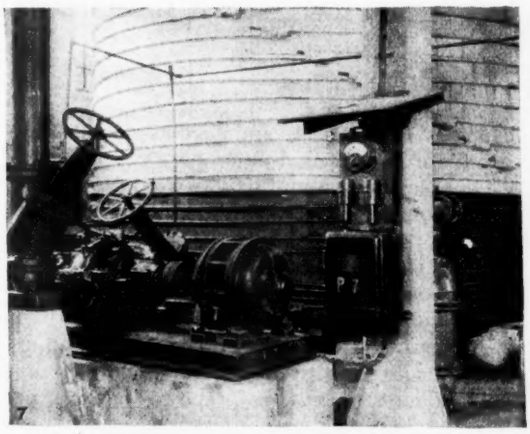


Fig. 8 shows typical centrifugal pump curves for constant speed. The efficiency is high and fairly flat from 70-ft. to about 97-ft. head and from about 4,000 to 5,600 gal. per min., hence the pump could be efficiently applied between these limits. The horse power falls off on either side of 5,000 gal. per min. delivery, so that the motor cannot be overloaded.

Operating Off Rating—Pumps are rated at their best operating point and any deviation in speed, head or delivery will result in a higher cost per unit of duty. While some future conditions may have to be given consideration, operating at lower than rated head should be avoided especially where a constant-speed motor is used. Fig. 9 shows the variations in kilowatt-hours per million gallon-feet pumped by a 10-in. centrifugal pump direct connected to a constant-speed motor which gives the highest over-all efficiency at the pump rating.

The gallon-feet pumped in a year at 135 ft. head for $9,100 (2c. per kw.-hr.) would cost $17,000 if pumped at 45-ft. head with pumps of this class. This difference of $7,900 a year is not out of line with many pumping duty costs that may be found among the misapplied pumps in industrial plants.

Choice of Motor—For constant-speed service either induction motors of the squirrel-cage type or synchronous motors may be used. Synchronous motors improve the power factor for the plant, and this item may be enough to justify the valve manipulation incident to starting centrifugal pumps with such motors, together with the complication of bringing direct-current excitation to the motor. There is little difference in the efficiencies of the motors mentioned.

For direct-current service shunt-wound motors are not well adapted for centrifugal pump drives as they are too sensitive to load and voltage changes. A compound-wound motor should be used with only a moderate

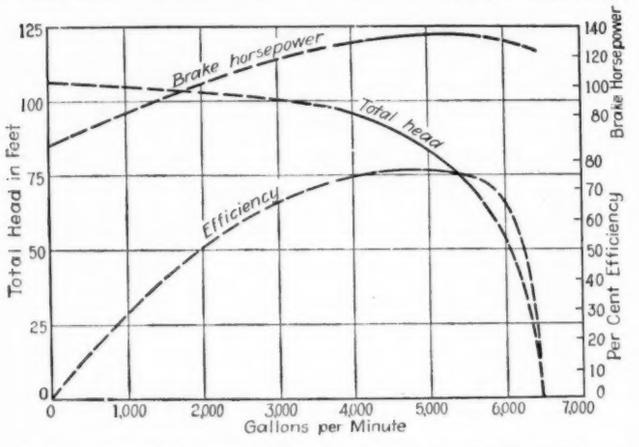


FIG. 8—TYPICAL CURVES FOR A 12-IN. CENTRIFUGAL PUMP AT CONSTANT SPEED

series field, say 10 per cent, and such motors have been standardized for centrifugal-pump service.

For adjustable-speed pump drives wound-rotor induction motors, or the brush-shifting commutator-type polyphase motors may be used. The latter have much higher efficiencies at reduced speeds, and this justifies their higher cost if operated at below normal speed frequently or for long periods. Fig. 10 shows the relative power input for an adjustable-speed pump using wound-rotor and brush-shifting motors, curves *B* and *A* respectively. The third curve, *C*, shows the high power consumption when throttling to get reduced output. At 60 per cent of normal pump output, 1,200 gal. per min., the brush-shifting motor would operate 24 hr., where power costs 2c. per kw.hr., for about $12; the wound-rotor motor for $15; and the squirrel-cage motor with throttled pump for $25. The differences become greater upon reducing the output still more.

Vertical motors may often be used to advantage by locating the pump at whatever depth may be necessary

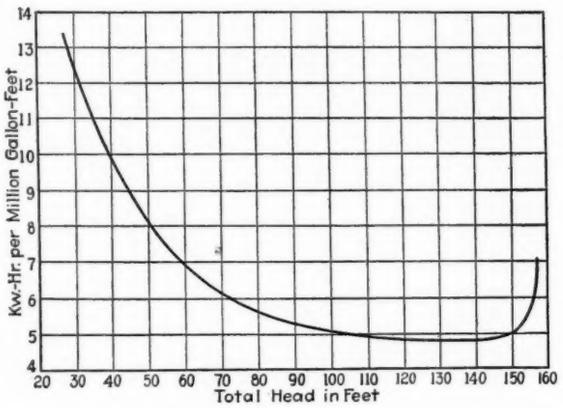


FIG. 9—CURVE SHOWS THE KW.-HR. REQUIRED PER MILLION GALLON-FEET AT VARIOUS HEADS FOR A 10-IN. CENTRIFUGAL PUMP DRIVEN AT CONSTANT SPEED

below the motor-room floor. This reduces or eliminates the suction lift with consequent benefit to the over-all efficiency. Where grit is present in the water or the pump is inaccessible, the entire weight of the revolving parts may be carried on a suspension thrust bearing at the top of the vertical motor. This allows of easy inspection and maintenance. Vertical motors are available in synchronous, squirrel-cage, wound-rotor, brush-shifting and direct-current construction.

Fig. 2 shows three brush-shifting vertical motors at the right and three squirrel-cage vertical motors at the left, all driving centrifugal pumps. Squirrel-cage motors can be used on centrifugal pumps up to 500-hp. provided the inrush starting current is not objectionable. Wound-rotor motors start with much less line disturbance and are used for that reason even when intended for constant-speed duty. Synchronous motors are not usually installed below 75-hp. and are of course for constant-speed duty only.

Reciprocating pumps, rotary pumps and screw pumps have heavy starting duty due to high-break-away torque and full-load pumping duty from start. For these reasons squirrel-cage motors cannot be used if line disturbance is objectionable. Synchronous motors can be used, but the pump must be relieved of its load in starting so that the motor can pull into step. Wound-rotor motors for alternating-current and compound-wound motors for direct-current are best for pumps of this class as they are possessed of strong starting characteristics. The brush-shifting commutator type alternating-current motor is equally good where adjustable-speed operation is desired.

Pump Control—Squirrel-cage motors are controlled by manual or automatic compensators to which may be attached disconnecting switches and ammeters. The automatic compensators may be actuated by a push button at some convenient point, by a float switch, by a thermostat or by a diaphragm pressure switch. Fig. 1 shows motors started with a manual compensator with ammeter attached and Fig. 3 a vertical squirrel-cage

motor direct connected to a sump pump and controlled by a float switch through an automatic compensator.

Wound-rotor motors for constant-speed duty are controlled by an automatic panel actuated by push button, float switch or the like. Fig. 4 shows wound-rotor motors driving reciprocating pumps and controlled by automatic panels and float switches. The heavy starting duty on the reciprocating pumps determined the type of motors used. Where adjustable speed is required or it is desired to control the starting by hand, a manual rheostat is provided in the secondary circuit, while the line contact is made by a manual or magnetic switch. Synchronous motors are commonly controlled by a compensator and a field-discharge switch. Brush-shifting motors require only some form of line switch

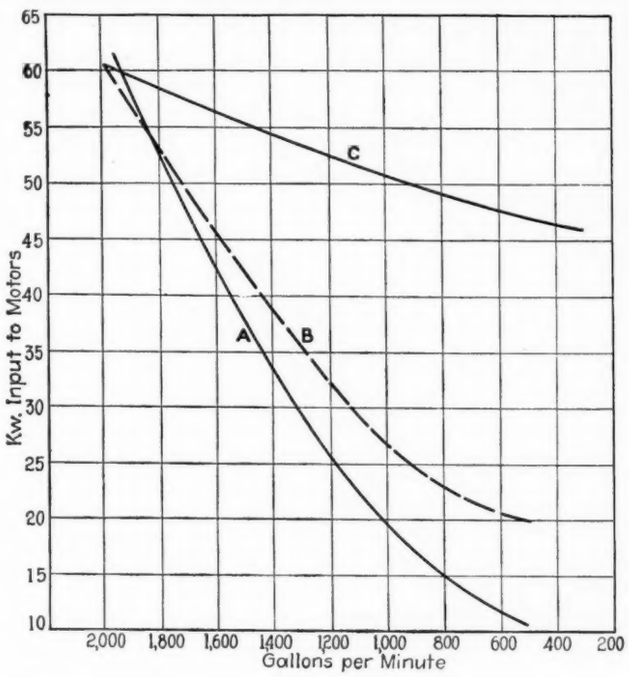


FIG. 10—CURVES SHOWING KW. INPUT TO MOTOR WHEN REDUCED PUMP OUTPUT IS SECURED BY REDUCING SPEED USING A BRUSH SHIFTING MOTOR *A*; BY REDUCING SPEED USING A WOUND-ROTOR MOTOR *B*; BY THROTTLING AT CONSTANT SPEED *C*

with overload protection and a mechanical means for shifting the brushes. This may be a handwheel, a shipper rod or a small pilot motor actuated by remote push buttons. Reference to Fig. 2 will show this form of speed control at *A* on the three brush-shifting motors at the left. The master panel is in the center background.

Compound-wound direct-current motors for centrifugal pumps require a disconnecting switch and a hand starter. If adjustable speed is required, a manual field-regulating rheostat is added. Direct-current motors may also be controlled by magnetic panels actuated by a push button, float switch or the like as in the case of the alternating-current motors. Fig. 5 shows compound-wound motors in a nitrate plant controlled by fused disconnecting switches and hand starters all neatly arranged.

Control apparatus in all cases should be fully inclosed and provided with overload and undervoltage protection. Where it is desired to have the motor restart by itself after an undervoltage shutdown, undervoltage release should be specified. Undervoltage release must also be provided if the motor is to be started by a float switch or other auxiliary-circuit closing device.

The presence of explosive gases or of corrosive acid fumes necessitates the submergence of contact making parts in oil. Such control items are available for all classes of pump service. Fig. 6 shows a battery of motor-driven gasoline pumps in a refinery. The switches are of the oil-immersed type, and as a squirrel-cage motor has no moving contacts there is no danger of starting a fire or explosion.

Fig. 7 shows an acid pump driven by a 40-hp. squirrel-cage motor, which is in no way injured by the fumes as there are no vital parts exposed. This motor is controlled by a standard compensator which has its contacts submerged in oil.

Pump Service—In conclusion it is to be noted that motor-driven pumps are successfully coping with every exacting class of service in industrial plants. Liquids, whether thick, light, volatile, acid or what-not, are all being handled under manual or automatic control with the greatest facility. The flexibility of electric drive allows the plant engineer to draw a straight line from level to level, put the pump in the line practically without bends, with the assurance that he can bring the power to the pump without any loss in efficiency or inconvenience to the plant.

Hints on Valve Setting

BY THOMAS W. AIREY

Various methods employed in setting the position of the eccentric sheave relative to that of the crank have from time to time appeared in the columns of *Power*. The writer ventures to add one more simple method, which may not be known to many readers and which, if carefully carried out, will give satisfactory results.

The center of the bore of the eccentric sheave is first found and also the center of the periphery of the eccentric as shown at *a* and *b*, Fig. 1. A line *CD* is then scribed across the face of the eccentric sheave passing through the two points *a* and *b*. The line *CD* is then indented with a fine center punch. This will be found valuable should the eccentric sheave require readjusting at any future time. A templet *T* is made to fit the crankshaft as shown in the figure, the edge *J* of the templet corresponding with the line *CD*, which is first set out on the sheet from which the templet is to be cut, *a b* being the throw of the eccentric and *G* a distance equal to the lap plus the lead, the top edge *K* of the templet being carefully trued up parallel with the axis *A* of the crank arm.

To use the templet first set the crank horizontal. This may be accomplished by the following method shown at Fig. 2. From the center of the crankshaft describe a circle *N* with a diameter equal to that of the crankpin *P* (should there be a collar on the crankpin, then *N* = diameter of crankpin collar). With a straight-edge *S*, one end resting on the crankpin and the other end set to coincide with the edge of the circle *N*, adjust the crank until the true level is found tested by a spirit level *L* resting on the top of the straight-edge *S* as shown in the figure.

If the crankshaft is in place in the engine frame and the connecting rod coupled up, then the level may be obtained by the method described later and illustrated at Fig. 4.

The crank being set horizontal, the eccentric sheave is turned around on the shaft with the corresponding edge of the templet lying along the line *CD* scribed on the sheave until the top edge *K* of the templet is perfectly horizontal when tested with the level *L*. The correct position of the eccentric sheave relative to the crank is thus obtained.

The distance *G*, which equals the lap plus lead, Fig. 1, depends upon the point in the piston stroke at which

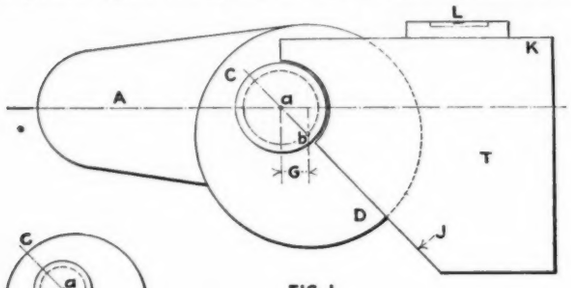


FIG. 1

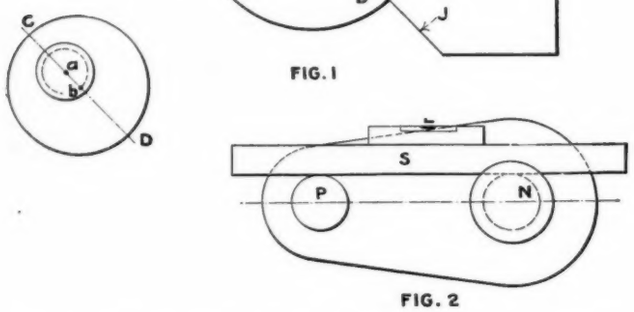


FIG. 2

FIG. 1—APPLICATION OF TEMPLET IN SETTING ECCENTRIC SHEAVE. FIG. 2—METHOD OF DETERMINING HORIZONTAL POSITION OF CRANK

it is desired the steam should be cut off, and can be determined by means of the diagram shown at Fig. 3.

Let *AB* represent the stroke of the piston, *CD* the position of the crank, *DCG* the angle of the crank at the instant the steam is cut off, *E* representing the point of cutoff and *DE* the length of the connecting rod. From *C* as a center, with a radius *CS* equal to half the travel of the valve, describe the circle *S* representing the path of the eccentric; join *SG* and along the line *SG* mark off the distance *aS* equal to the lead; bisect *aG* in the point *b;* then *ab* equals the lap required with the lead *aS* to cut off at *E* in the piston stroke, and the distance *bS* is the distance marked *G* in Fig. 1. Having fixed the position of the eccentric sheave on the crankshaft, we may now adjust the position of the valve so as to give the required lead at each end.

Turn the crank around until it is nearly on the center as at *A*, Fig. 4, and from some fixed point as at *D* with a trammel of any convenient length mark and center punch the point *a* on an arc struck from the center of the shaft on the flywheel, pulley, or any suitable revolving piece; also mark the position of the crosshead on the guide as at *G*. Now turn the engine around in the direction of the arrow past the center *C* until the crosshead reaches the same point *G* relative to the guide. When in this position mark the point *b* corresponding with the crank at *B* by means of the trammel, having one end in the first point *D* as before. Bisect *ab* at *c* and turn the engine back until the trammel coincides with point *c*. The crank will then be on the dead center. The valve may now be adjusted on the valve spindle to give the desired lead at this end.

Turn the engine around on the opposite dead center, when the lead may be checked at that end. If we check over the points of cutoff, we shall find there is a difference on the forward and return stroke of the piston. This is due to the angularity of the connecting rod, the crank not having turned so far during the forward stroke when the piston has reached its point of cutoff as it has for the same percentage of travel during the return stroke.

In Fig. 5 let *J* represent the position of the crankpin when the piston has reached a point *G* in the piston stroke, while *F* represents the crankpin in a diametrically opposite position, the distance the piston has traveled on its forward stroke being represented by *a g* (*A G*) while the distance traveled by the piston on its return stroke is represented by *b d* (*B D*), and it will be seen that *bd* is less than *ag*.

It will also be seen that the shorter the connecting rod the greater will be the distance traveled by the piston in its forward stroke, while on its return stroke

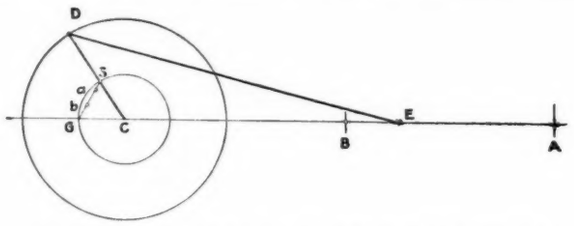


FIG. 3—FINDING LAP AND LEAD WITH GIVEN POINT OF CUTOFF

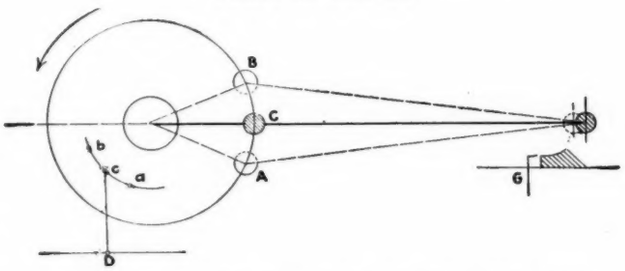


FIG. 4—SETTING CRANK ON DEAD CENTER WITH USE OF TRAMMEL

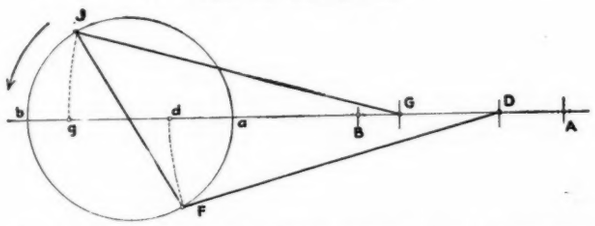


FIG. 5—ANGULARITY OF CONNECTING ROD AFFECTS POINT OF CUTOFF

the distance traveled will be less; or the longer the connecting rod the more nearly would the distances *ag* and *bd* coincide.

The obliquity of the valve rod being much less than that of the connecting rod, the position of the valve therefore is not affected so much as that of the piston.

In the preheater installation at Colfax it is evident that the only item questionable is the preheater-element construction. There has been, up to the present time, absolutely no indication of deterioration in this connection, and in addition the reduced amount of equipment required for the preheater installation in comparison with an economizer installation naturally reduces maintenance charges.—*C. W. F. Clarke*

No End Thrust in the Bonom Radial-Flow Turbine

The advantage of a radial-flow turbine lies chiefly in the fact that it may more readily be built for double-rotation than the usual axial-flow type, and hence inherently contains about one-quarter as much blading as an equivalent single-motion reaction unit. The Bonom turbine is designed to suit American manufacturing methods and may readily be arranged for reversible drive. For marine service it is estimated as weighing, in some cases, one-half as much per horsepower as the present type of propulsion turbine, with an efficiency of about one-fourth more, and is especially adapted to propelling vehicles and locomotives.

THE lack of success of the radial-flow type turbine in this country is attributed by many to the exacting requirements of manufacture. The Bonom type is designed to suit commercial manufacturing processes as well as to eliminate or reduce end thrust ordinarily characteristic of these machines.

A radial-flow type can be built as a "double-rotation" machine, where alternate blade rows move in opposite directions. The axial-flow type has not yet been commercially adapted to double motion. The double-motion turbine inherently contains about one-fourth as much blading as a single-motion machine. Leakage loss is relatively less for the high-pressure vanes. Progressively increasing blade-row diameters are better suited to full peripheral admission for the high-pressure stages and to increasing steam volumes. The velocity of the steam can be made more nearly equal to that of the blades which it enters than is practicable in axial-flow single-motion turbines of the same number of blade rows. This tends to give better efficency. The two-phase design permits lower rotational speed and greater capacity than that for present commercial radial-flow turbines.

The principles of radial-flow construction are illustrated in Fig. 1. The cross-sectionings are intended to illustrate the purpose or function of the various members rather than the actual material of which they are made. At *A* is an approximation of the usual radial-flow design. The rotor at the left rotates in one direction and the rotor at the right in the other. Steam enters through the stationary casing and is admitted through ports in the revolving rotors to the interior of the center ring. It will be noticed that the center ring in this case is attached to the left-hand rotor by a bulb construction, representing a ball-and-socket joint. The blade ring is built somewhat like a squirrel cage, and the photograph of a Bonom-type blade ring from an actual turbine is given in Fig. 3. After the steam is discharged from the first blade ring, it enters the second, traveling in the opposite direction, and then is discharged to the third, traveling in the original direction. From there it is exhausted.

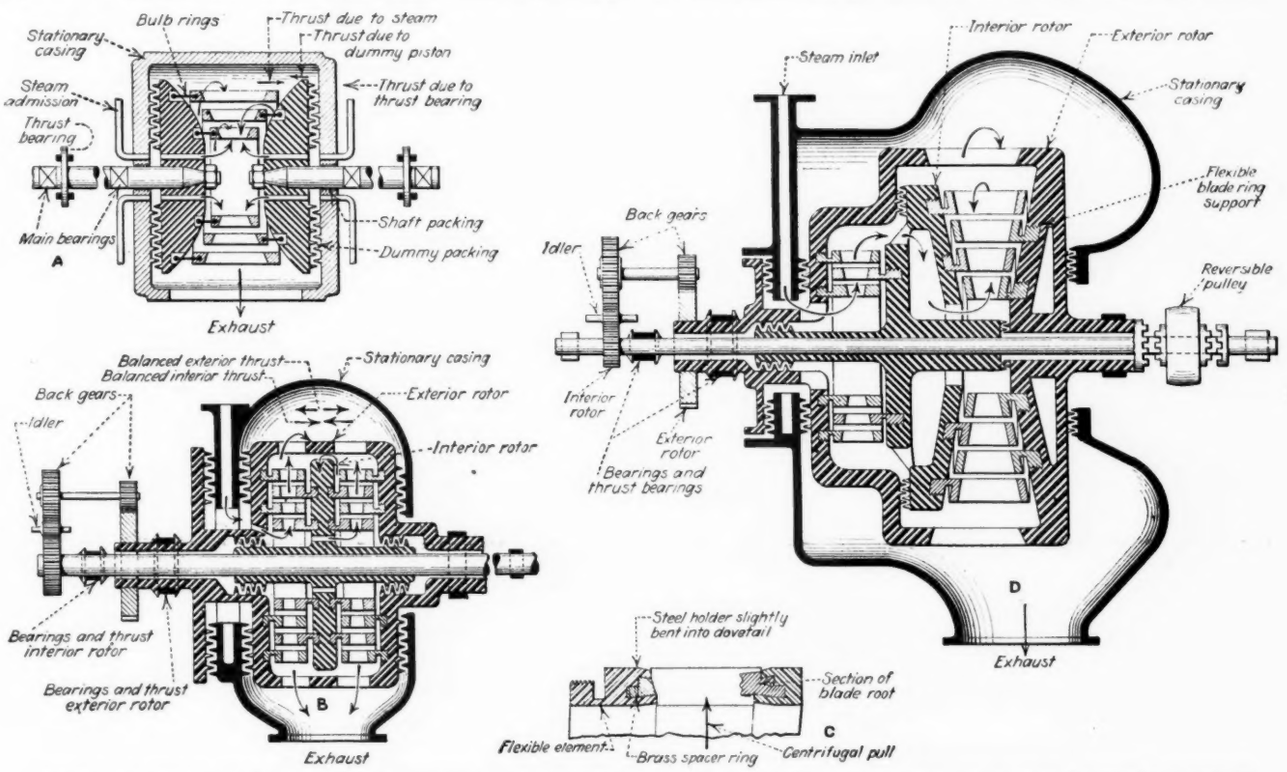


FIG. 1—RADIAL-FLOW TURBINES WITH AND WITHOUT END THRUST. FULL END THRUST REQUIRES DUMMY PISTON AT *A*, NO END THRUST IN DOUBLE FLOW AT *B* AND THRUST BALANCED FOR DESIGNED LOAD AT *D*

This type of turbine requires two generators, one on each shaft. It will be noted that the steam pressure tends to push the two rotors apart when operating at full load. When running light, condensing, it is probable that the vacuum might be more effective than the actual steam pressure, so that the disks would tend to be pulled together. The thrust at full load is neutralized to a large extent by the steam pressure between each rotor and the stationary casing. The labyrinth packing at this point, which constitutes the "dummy piston," controls the leakage of steam, so that sufficient pressure is held against the disks to counterbalance the thrust due to the steam in the interior. Thrust bearings of radial steel collars against flat babbitt surfaces are supplied on each shaft, in order to maintain the axial positions of the rotors and absorb any unbalanced thrust.

A Bonom type of small turbine, in which there is no end thrust, is shown diagrammatically at *B*. Here the steam travels in two paths, so that it represents a double-flow turbine, in which the thrust is automatically neutralized.

The interior rotor revolves in one direction and contains two blade rows on each side. The exterior rotor revolves in the opposite direction, containing four additional blade rows. It will be seen that the thrust on each side of the interior rotor neutralizes itself, at all loads being in opposite direction but equal. A balancing piston is not necessary. The labyrinth packing shown in the illustration may be varied considerably so that it does not represent a dummy packing for balancing thrust. The shaft is contained in two bearings, one at each end. The liners at the left also contain thrust bearings which consist of collars on the shaft bearing against radial bearing faces. Expansion, therefore, is free to take place in a right-hand direction. Kingsbury-type thrusts are utilized in large-sized machines.

The exterior rotor revolves around the shaft and is given a considerable clearance over the shaft. This is in a direction opposite to that of the interior rotor.

The double-flow turbine may be equipped with two generators, similar to that in *A*, Fig. 1. In such a case one generator would be coupled to the shaft in the interior rotor on the left and another generator to the revolving part of the exterior rotor at the right. However, one generator may be used for both rotors if desired, by placing gearing between the two rotors so that power will be received from each one, in spite of the fact that they revolve in opposite directions.

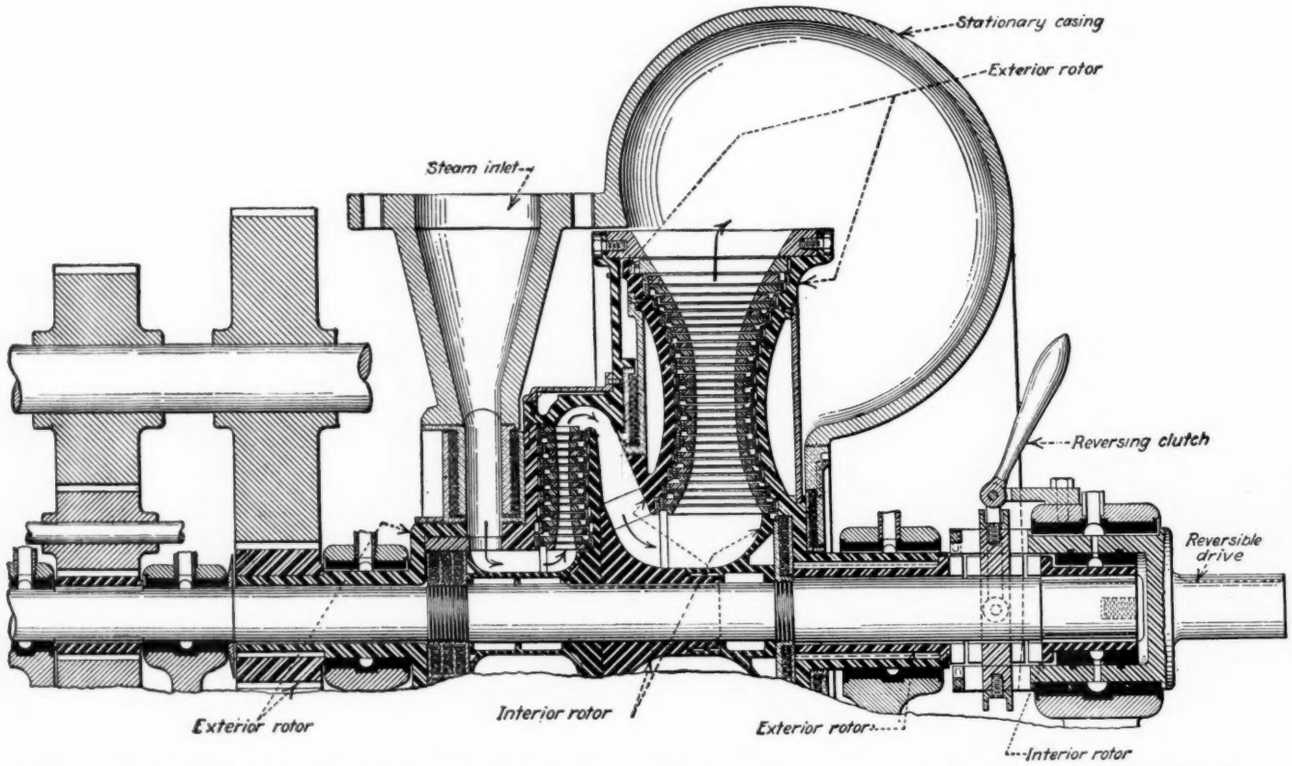


FIG. 2—TWO-PHASE TURBINE PERMITS LOWER ROTATIONAL SPEED AND GREATER CAPACITY THAN USUAL RADIAL-FLOW DESIGN. CROSS-SECTIONING IDENTIFIES THE ELEMENT RATHER THAN ACTUAL MATERIAL

Back gearing of this kind is indicated at the left, at *B*. Power may be then taken from the interior shaft in one direction, or it may be taken from the exterior rotor in the other direction, such as designed. A pulley may be rigged up so that it can be clutched onto either the interior or the exterior rotor. The pulley may therefore be run in either of the two directions. This provides a means of obtaining both rotations for the element to be driven, if desired, so that a turbine of this character may be readily adapted to marine or land propulsion.

At *D*, Fig. 1, is indicated a different design of Bonom turbine, which is not double-flow. In this case the steam is not split up into two different streams as at *B*. The arrows indicate the path of steam received through the stationary casings and passed through the first expansion, which contains three blade rings. The thrust on the interior rotor is in one direction for the high-pressure path and in another for the low-pressure path. The turbine may be so proportioned that the actual thrust is balanced at any load, and therefore no end

thrust exists on either the interior or exterior rotor. If the load is changed, of course some thrust will appear, in accordance with the amount of the change of the load. Thrust bearings are provided to take care of any partial unbalance that would occur when the turbine ran at load other than that for which it was designed. It is possible to utilize dummy packing to neutralize thrust for definite changes of load if desired. In practice, however, thrust bearings may take care of this differential. By placing another two-phase unit on the same shaft, the double-flow principle may be employed, which is balanced against thrust at all loads. One steam inlet and one exhaust opening may then suffice.

A two-phase machine, designed for 594-kw. capacity at 115 lb. abs., 50 deg. superheat steam, 28-in. vacuum and

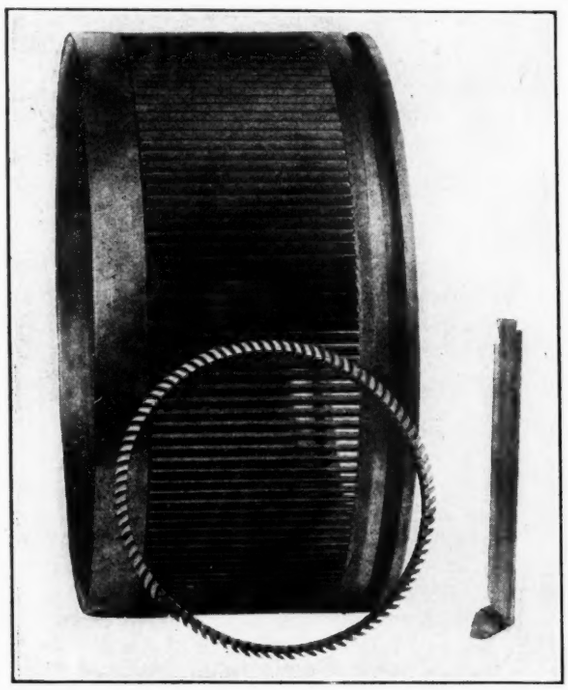


FIG. 3—BONOM BLADE RING, SHOWING STANDARD BLADE AND BRASS SPACER RING

2,500 r.p.m. is indicated in Fig. 2. This is proportioned to produce zero end thrust at full load. Thrust bearings are indicated at the left, as well as the back gearing. Here is a shaft extension for a coupling, which may be operated in either direction by means of a clutch. It is necessary to stop the turbine in changing the rotation of the clutch, as in this case it does not contain a friction element. Two or more sets of back gearing may be used in accordance with requirements of the design. There are 48 blade rings in this machine, 16 of which are in the high-pressure phase at the left.

In Fig. 1 at *A* is indicated a general plan of bulb supporting member which tends to hold the blade ring in place, with a sort of hinge or ball-and-socket joint. This is characteristic of the European type of radial-flow turbine.

The blade ring of the Bonom turbine substitutes a special flexible element in place of the ball-and-socket construction. In Fig. 1 at *C* is shown the cross-section of part of a blade ring of a small turbine. The blade rings are screwed into threaded recesses in the turbine disks, as shown at Fig. 1 at *C*. Just outside of this attachment the blade ring is greatly reduced in cross-section, representing the location of the special flexible expansion element.

A blade ring that contains a recess for flexibility is shown in Fig. 3. In this particular instance the blade ring, instead of being fastened by threads to the disk, is fastened by rolling a projection of the disk over a conical surface of the blade ring. This construction has been supplanted by the threaded joint.

In order to obtain blading easily manufactured, vanes themselves are made in continuous pieces, by drawing through dies and cutting off at suitable lengths. Each end is dovetailed, similar to the blade shown in Fig. 3. The dovetailed vanes are automatically spaced by a brass spacing ring, also shown standing up in the figure. Steel reinforcing rings at each end are slotted to receive the tapered ends of the blades. They are fastend by being rolled into the dovetail. This assembly is shown in Fig. 1 at *C*, being characteristic of small machines.

A turbine of 2,000 kw. capacity has been designed for saturated steam at 165 lb. abs., 28-in. vacuum and a rotor speed of 1,500 r.p.m. A high-blade speed to steam speed ratio of 0.7 was adopted. The blades in all cases have been assumed to be Parson's standard types, and with the exception of the eleven last rows of blades of the second stage, they are all ¼-in. set at a third pitch and $\frac{1}{16}$ in. clearance, and will give (according to Martin) an angle of discharge of 18 deg. 20 min., and an efficiency ratio of at least 75 per cent.

Making this ratio of blade speed to steam speed constant throughout the turbine greatly simplifies all the steam calculations. The steam speed of exit or inlet of any row of blades becomes a function of the diameter. There are 26 rows of blades in the first phase. The outlet pressure is 59.2 lb. per sq.in. abs. There are 43 single rows of blades in the second phase. The blades of the last seven rows have had their angle of discharge opened slightly so as to allow keeping their length short enough to avoid undue bending moment stresses. The angle of discharge of the last-row blades is 23 deg. 8 min. Smallest axial clearance is $\frac{3}{16}$ in. The size of the shaft has been chosen so as to allow a margin of 20 per cent increase in speed before the critical speed is reached. The bevel gears have been calculated for a tooth pressure of 670 lb. per in. and a speed of 105 ft. per sec. Detailed weights are given in the table.

The weights of the different parts of the turbine are as follows:

	Lb.
Interior rotor on inlet bearing	330
Interior rotor on outlet bearing	594
Exterior rotor on inlet bearing	574
Exterior rotor on outlet bearing	769
Casing and inlet pipe	1,910
Gear case	1,250
Outlet bearing	100
Base	840
	6,367

This gives a total of 6,400 lb., or 2¼ lb. per horsepower.

The very short rotors, in this case 17 in., and their light weight permit the use of a shaft much smaller than that of any other turbine of the same power. This allows the use of glands, the clearance of which is reduced on account of this small size.

Alfred Bonom[1] has domestic and foreign patents covering various applications, such as propulsion for locomotives, automobiles, power-plant auxiliaries, etc., having spent many years involving the design and construction of these machines.

[1]Room 405 of 99 John Street, New York.

Diesel Engines for Water-Pumping Plants

THE economy of Diesel engines in pumping plants of various types indicates their suitability for water works service. A comparison of operating costs shows that the oil engine is equal if not superior to other forms of power, while its life is such that depreciation is a minor element in the total operating charges.

BY A. R. McMULLIN

WHILE a water-pumping plant and the distribution system may not offer as much of interest to the spectator as does the central station and its mass of transmission lines, nevertheless a plentiful and cheap supply of water is as essential as is cheap electric power to the well being of a state. It is not surprising, then, that Diesel-driven units are coming into favor for such service.

For many years crank-and-flywheel triple-expansion and double-acting cross-compound units monopolized the water-works pumping field. Then turbine-driven centrifugals came into favor because of lower initial cost, smaller space requirements and an economy approaching that of the reciprocating pump. In many cases electrically driven centrifugal pumps have been chosen, with energy obtained from an outside source. To insure continuity of service, it is by no means unusual to provide auxiliary pumps driven by internal-combustion engines.

In the last few years water-works engineers in this country have included Diesel-driven plunger and centrifugal pumps in their studies. In nearly all cases it has been found that the total cost of pumping would be less with the oil engine than with any other prime mover. Apparently, the reasons why Diesels have not been chosen for the large water-works, were the higher

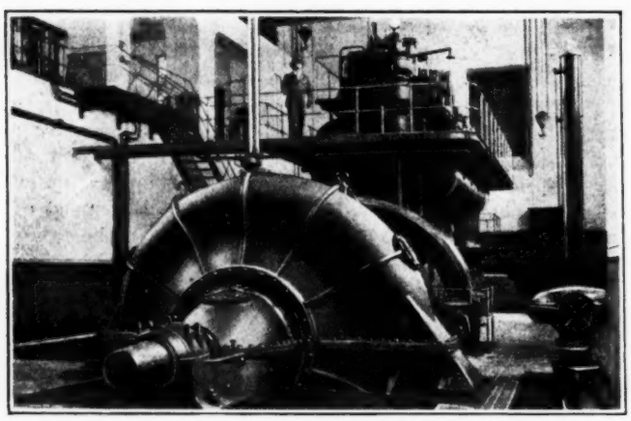


FIG. 1—2,000-HP. DIESEL DRIVING CENTRIFUGAL IRRIGATION PUMP, KOM OMBO, EGYPT

first cost and the fact that there are no very large units operating pumps in the United States.

In this respect we lag far behind foreign countries, where the higher economy of the Diesel pumping unit has caused a number of installations to be made. The 2,000-b.hp. engine and direct-coupled centrifugal pump, shown in Fig. 1, were built by Sulzer Brothers for the extension of the Egyptian Irrigation Plant at Kom Ombo belonging to the Wadi Kom Ombo Company.

In order to avoid an excessive suction lift, the floors of the pumprooms of most Egyptian pumping stations are placed several feet below the ground level. This requires an extremely strong wall construction so as to hold back the Nile at flood times. As the cost of such building construction is extremely high, it can be seen that the small space required by the oil engine keeps down the capital expenditure.

The impeller of this pump is 110 in. in diameter. Its

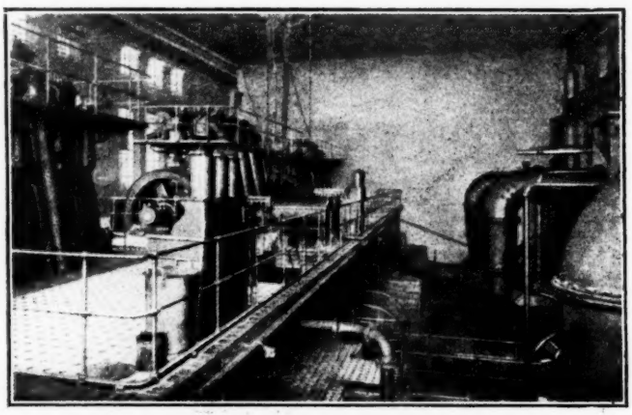


FIG. 2—THREE 800-HP. DIESELS IN RUSSIAN WATER-WORKS

capacity is approximately 70,000 gal. per min. against a total head of 79 ft. when the pump operates at 134 r.p.m. The official tests showed a fuel consumption of 0.534 lb. per water horsepower, the fuel oil having 18,500 B.t.u. per pound.

The installation shown in Fig. 2 consists of three 800-b.hp. Diesels driving pumps in the main sewage pumping station in Moscow, Russia. Because the lift was greater than could be handled by direct-connected centrifugals the pumps were speeded up through rope drives. This form of transmission made it convenient to place the pumps in a pit and keep the engines at a higher level on solid ground, thereby reducing the cost of foundations. The sewage is pumped from a collecting tank through a cast-iron pipe 3 ft. 3 in. in diameter and over 5 miles long.

Although the larger solids are removed by 1¼-in. gratings in the suction line, the impellers become fouled. However, it has been found that the foreign matter will drop from the impellers when the pump speed is reduced about 40 per cent. This cleaning operation takes from 20 to 30 seconds and is based on the fact that the pump, when running slowly, is unable to maintain full head and, although turning in the normal direction, allows the liquid to fall back into the suction basin.

For many pumping conditions single or multi-stage centrifugals direct-coupled to Diesel engines can be used. Fig. 3 shows a 50,000-g.p.m. unit of this type operated by Donna Irrigation District at Donna, Tex. Where the total lift is too great for centrifugal pumps unless operated at speeds deemed too high for the engine, resort may be made to speeded-up centrifugals. As an alternate it is well to consider single- or double-acting plunger pumps geared to the engine.

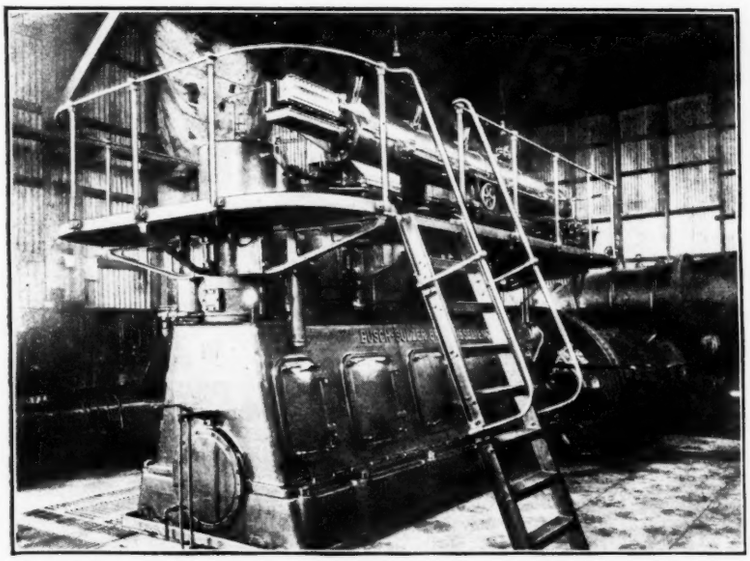


FIG. 3 (ABOVE)—DIESEL ENGINE DRIVING CENTRIFUGAL PUMP, DONNA IRRIGATION DISTRICT, TEXAS

wear of valves and plungers, space available and maintenance expense, may favor centrifugals at times, the higher efficiency of plunger pumps over centrifugals, amounting to 10 per cent or more, including gear losses, will frequently compensate for their higher first cost. Fig. 5 shows two Diesel engines driving triplex pumps at Sioux Falls, South Dakota, these being installed in 1916. Pumping was previously done by one vertical triple-expansion steam unit, shown in the background, and one horizontal cross-compound steam pump. Cost of fuel, lubricants, waste and repairs for pumping by steam was $20.48 per million gallons and has been cut by the oil engines to $10.61, the new equipment saving its cost in less than five years.

There has been a tendency among engineers to handicap the Diesel with a short assumed life when comparing it with other

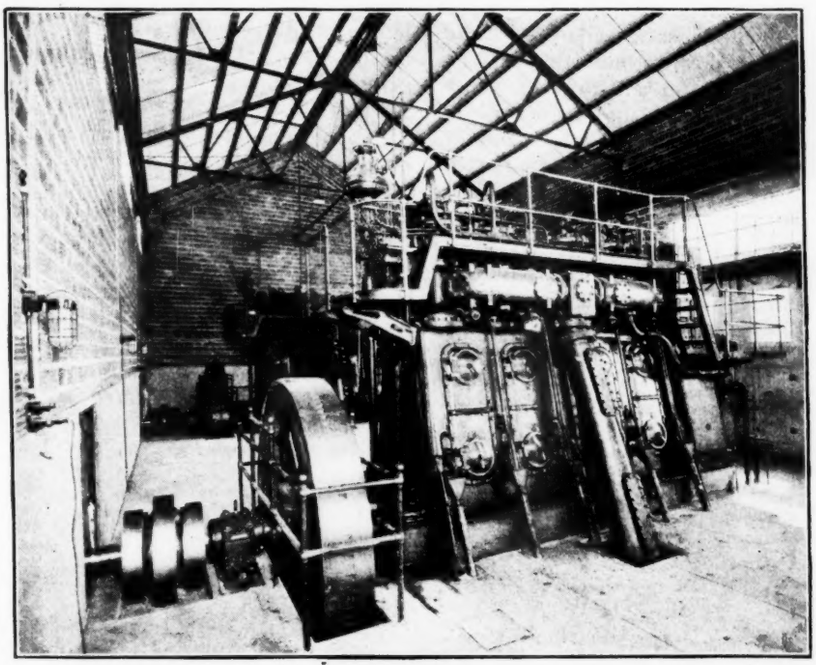


FIG. 4 (RIGHT)—TWO 750-HP. DIESEL ENGINES DRIVING PIPE-LINE PUMPS, SINCLAIR PIPE LINE CO., HUMBOLDT, KAN.

FIG. 5 (BELOW)—TWO DIESELS DRIVING VERTICAL TRIPLEX WATERWORKS PUMPS, SIOUX FALLS, SO. DA., REPLACING VERTICAL TRIPLE-EXPANSION STEAM UNIT SHOWN IN BACKGROUND

That the plunger-pump unit is both reliable and efficient is proved by the fact that there are several hundred Diesel engines geared to reciprocating pumps operating at about 700 lb. pressure in regular service in oil-pipe-line pumping stations. In a large number of cases they have displaced triple-expansion steam engines which were originally installed, and there has resulted a saving of approximately 75 per cent in the amount of fuel oil used for the same duty. Fig. 4 shows installation of two 750-b.hp. engines in the Humboldt, Kan., station of the Sinclair Pipe Line Co. The extension of the engine shaft passes through a fire wall to the pumproom, where it gears with the pump shaft. The fire wall eliminates all danger of fire in case a pump should break and flood the pumproom with oil.

Although other factors, such as foreign matter carried by the water causing rapid

types of prime movers, and charging it with too large an expense for maintenance. This is a grave error, for of the older engines built by the Busch-Sulzer Bros. there are: 21 Diesels operating in their 20th year or longer; 47 in their 19th year or longer; 76 in their 18th year or longer; 125 in their 17th year or longer; 130 in their 16th year or longer; 137 in their 15th year or longer. Considering engines of over 100 hp., of the total number sold by this company in the last 20 years, 96.7 per cent are in service, 2 per cent are for re-sale, of 0.66 per cent there is no record, and 0.64 per cent have been scrapped.

With normal replacement of such wearing parts as bushings, valves, pistons and cylinder liners, it is conservative to assume that a modern Diesel built by an experienced manufacturer has a useful life of more than 25 years.

It has frequently been the practice to handicap the Diesel further by figuring a flat rate of depreciation at a certain yearly percentage depending on the years of life assumed for it; that is, for a life of 15 years to charge 6⅔ per cent depreciation, etc.

If an amount is actually set aside as a sinking fund to replace the equipment when worn out, this charge can be greatly reduced. Assuming a life of 25 years for a well-built engine, the sinking fund necessary to replace the engine is not 4 per cent, but is that amount which, if set aside annually and reinvested at prevailing interest rates, will retire the capital in 25 years. With a 5 per cent return on such a sinking fund, the amount to be set aside is only 2.095 per cent. This, then, is the correct percentage of the initial investment to charge as a sinking fund for replacement.

Available records show that the annual expense necessary to maintain a modern Diesel in good operating condition will not exceed 2 per cent of the engine cost. During the first few years this item will be considerably under 1 per cent and will gradually increase until the replacement of worn pistons, liners and valves, together with the rebabbitting of bearings, have been made. After thorough overhauling the maintenance expense will fall to an amount practically the same as during the first few years of the engine's life.

There is no obsolescence to be charged against the Diesel inasmuch as the improvement in economy of modern engines over the first ones built is so small that replacement of the earliest units is not justified from viewpoint of lower fuel consumption of later types.

As a concrete example of comparative pumping costs take the case of a city requiring an average of ten million gallons of water per day pumped against a total head of 350 ft. for which consideration is given to Diesel-driven triplex pumps, vertical triple-expansion steam pumps, turbine-driven centrifugal pumps and motor-driven centrifugal pumps.

The installation costs, operating and fixed charges with each type are shown in Table I. The Diesel plant shows a yearly saving of over $30,000.

That the replacement of many existing plants by Diesel units would result in tremendous savings is indicated by the fuel consumption of five plants, as given in Table II.

Plant A is the North Point station at Milwaukee, which is equipped with vertical triple-expansion units having the high test duty of about 180 million foot-pounds.

Plant B is a small Pennsylvania station with hand-fired boilers and cross-compound pumping engines.

Plant C is the newest Chicago station equipped with vertical triple-expansion pumping engines and turbo-centrifugal pumps, water-tube boilers operating at 175 lb. pressure and other modern equipment.

Plant D is the new Des Moines station equipped with stoker-fired boilers operated at 200-lb. pressure, 100-

TABLE I—OPERATING COSTS IN 10M GALLON PUMPING PLANT

Plant Equipped with	Diesel Engines, Triplex Pumps		Triple Expansion Steam Pumps		Steam Turbines, Centrifugal Pumps		Electric Motors, Centrifugal Pumps	
Building:								
Pumproom (basement to eaves), ft.	66x86x42		54x88x52		50x84x42		50x60x32	
Boiler room, ft.	.....		44x58x30		44x58x30		.....	
Fuel storage, ft.	30x50x12		25x58x12		25x58x12		.....	
Cost of above items		$69,000		$100,000		$83,000		$48,000
Equipment installed:								
	3-750 BHP diesels	$213,600	1-12 MGD unit	$160,000	1-12 MGD unit	$44,500	1-12 MGD unit	$23,200
	3-10 MGD pumps	123,750	1-10 MGD unit	140,000	1-10 MGD unit	40,500	1-10 MGD unit	20,200
			1-8 MGD unit	125,000	1-8 MGD unit	37,500	1-8 MGD unit	13,200
			3-300 HP boilers	33,000	3-350 HP boilers	38,500	Switchboard and wiring	400
							Transformers	6,500
Foundations for pump sets		11,250		4,000		1,400		1,400
Suction and discharge piping		50,000		51,000		50,000		50,000
Total investment		$467,600		$613,000		$295,400		$162,900
Yearly Operating Costs:								
Labor:								
	1 chief engr.	$3,000	1 chief engr.	$3,000	1 chief engr.	3,000	1 chief engr.	$3,000
	3 asst. engrs.	5,400	3 asst. engrs.	5,400	3 asst. engrs.	5,400	3 asst. engrs.	5,400
	3 oilers	4,500	3 oilers	4,500	3 oilers	4,500	3 operators	4,500
			3 firemen	4,500	3 firemen	4,500		
Fuel:								
Oil at $1.70 per bbl.	9,010 bbl. oil	15,317	22,163 bbl. oil or	37,678	33,204 bbl. oil or	56,447	Elec. energy at 1¼ cent	$68,219
Coal at $6.75 per ton			5,600 tons coal		8,360 tons coal		per KWH	
Lubricating oil and waste		1,000		300		600		200
Maintenance and Repairs:								
Building, foundations, piping	130,250 at 0.5 per cent	652	$155,000 at 0.5 per cent	775	$134,400 at 0.5 per cent	672	$99,400 at 0.5 per cent	497
Machinery and equipment	337,350 at 2.0 per cent	6,747	458,000 at 1.5 per cent	6,870	161,000 at 1.7 per cent	2,737	63,500 at 1.7 per cent	1,080
Total		$36,616		$63,023		$77,856		$82,896
Fixed Charges:								
Interest at 5 per cent on Sinking fund	$467,600 or	$23,380	$613,000 or	$30,650	$295,400 or	$14,770	$162,900 or	$8,145
Building (Assumed Life 50 years)	0.5 per cent on $69,000	345	0.5 per cent on $100,000	500	0.5 per cent on $83,000	415	0.5 per cent on $48,000	240
Equipment	(25 year life or 2.1 per cent on $398,600	8,371	35 year life or 1.1 per cent on $513,000	5,643	25 year life or 2.1 per cent on $212,000	4,460	25 year life or 2.1 per cent on $114,900	2,413
Total		$32,096		$36,793		$19,645		$10,798
Total Yearly Expense		$68,712		$99,816		$97,501		$93,694

deg. superheat; the pumps are steam turbo-centrifugals of 143,000,000 ft.-lb. test duty. Iowa coal of 8,300 to 8,800 B.t.u. is burned.

Plant E represents a plant operating duplex compound pumps with 90-lb. steam pressure under a high pumping head.

With Diesel-driven centrifugal pumps the fuel oil required per million gallons of water pumped 100 ft. high would amount to not more than 32 gallons.

TABLE II—TYPICAL STEAM PUMPING PLANT PERFORMANCE

Plant	Average Daily Pumpage, Million Gal.	Total Head, Feet	Coal, Tons	Coal per Mil. Gal 100 ft. High, Tons
A	62.6	211.5	18,954	0.399
B	3.86	240.	1,800	0.53
C	76.5	115.3	18,452	0.572
D	10.9	283.5	3,237*	0.684
E	0.65	294.	770	1.10

* Five months period.

Credit is due Dabney H. Maury, consulting engineer, of Chicago, and Donald H. Maxwell, of Alvord, Burkick & Howson, consulting engineers, Chicago, for some of the data in this article.

Republic Boiler Indicator

To meet the requirements for a simple inexpensive indicating steam-flow meter adapted for use in small plants equipped with boilers of 1,000 sq.ft. or less, or in plants of greater capacity where a large number of smaller units are being replaced gradually by larger boilers, the Republic Flow Meters Co., of Chicago, has developed the instrument shown in the illustrations. In principle it is much the same as the larger standard electric flow meter made by this company but built on a smaller scale, more compact and simplified to a great extent. Withal it is claimed that an accuracy within 1½ per cent of the maximum capacity of the meter has been retained.

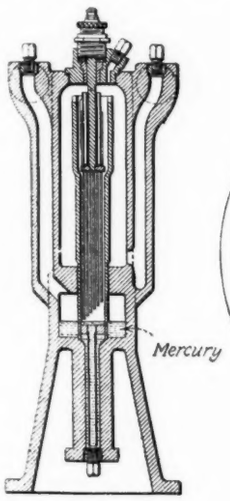


FIG. 1 VERTICAL SECTION THROUGH METER BODY

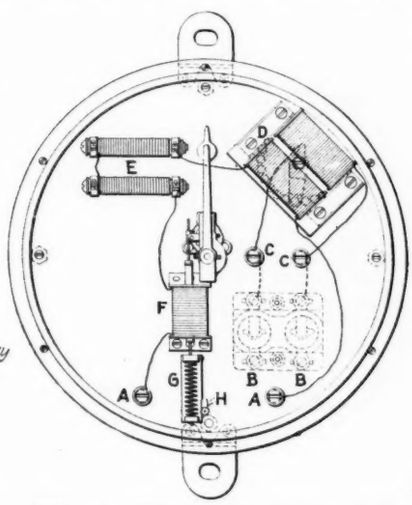


FIG. 2—INDICATOR WITH THE DIAL REMOVED, SHOWING THE ACCESSORY APPARATUS

As with the standard meter an orifice disk or a pitot tube is used to obtain the differential pressure of the flow. The meter body has been rearranged as indicated in Fig. 1. The scale, consisting of two concentric coils of resistance wire tapped at intervals with a number of rods extending down into the contact chamber, has been simplified. The number of contact rods has been reduced and the U-tube mercury connection from the high- to the low-pressure side has been modified to the simpler construction shown in the drawing. The mercury safety seal, protecting the meter body from sudden surges in pressure and by serving as an oil reservoir, preventing water entering the meter body and coming in contact with the resistance elements, has been retained.

The indicator is designed specially for boiler mounting. It is self-contained as all the accessory apparaus, such as the transformer, the external resistance and the solenoid operating the pointer, are inclosed within the dustproof case of the instrument. The arrangement is shown in Fig. 2. The terminals *AA* receive the wiring connections from the meter body. The local source of current is tapped to the two lower terminals *BB* of a double fuse block and passes into the case through the terminals *CC* which connect with the primary of the transformer *D*, designed to step down the voltage to 20 volts. In series with the secondary of the transformer are the external resistance *E* and the solenoid *F* of the indicator, mounted vertically to move the pointer over an arc of 300 deg. The motion of the solenoid core is transmitted to the pointer by a fine gear meshing with a pinion on the pointer shaft. To the bottom of the core a coiled spring member *G* is attached as a retarding force, and in addition it serves to keep the core in alignment. A gear *H* turned by a knob on the back of the case, permits adjustment for the zero position. A second knob controls the maximum adjustment by turning a set nut on the threaded rod extending above the core. The dial of the indicating instrument is 12 in. in diameter, with figures 1 in. high, giving readings directly in boiler horsepower based on an evaporation of 30 lb. of water per hour.

A possible explanation has been offered by the Power Generation Committee of the American Electric Railway Association for the relation between the rate of driving and slagging trouble. It is frequently noted that high rates of combustion are accompanied by relatively thick fires or by high draft losses through the fire and grate. This, in effect, reduces the percentage of excess air resulting in higher CO_2 with increased rates of combustion. At least for certain coals, thoroughly oxidized slag is powdery in form instead of plastic, so that a reduction in the excess air by making oxidation of the slag difficult, is liable to be accompanied by a change in the slag from the powdery to the plastic form with attendant grief. While the tentative theory has not been substantiated for a large variety of coals, it suggests one possible reason for the increase of slagging troubles with higher rates of combustion and the deduction is made that in small furnaces and with slagging coals, high CO_2 should be avoided at high rates of combustion.

Many a poor fellow has dragged through life burdened by a sense of incompetency and inferiority, deterred from aspiring to greater things, handicapped in his capabilities, and often denied the better opportunities of rendering the practical service of which he is capable, because he lacks an education. Most of these men have normal brains and bright, active, intelligent minds. The only reason that it is difficult for them to deal with problems requiring mental effort is that their thought processes are not developed.

The Value of Instruments for High-Grade Boiler-Room Operation

By HARRY H. BATES*

THREE-FOURTHS of the power-station operating expenses are spent in the boiler room. That alone shows the need not only for efficient equipment, but also for the various instruments and auxiliary apparatus necessary to generate steam efficiently. Of even greater importance are highly intelligent operators who are capable of analyzing their problems. The use of instruments is discussed, including a summary of boiler conditions and their symptoms or characteristics as indicated by meters.

IN THE first place, it is not fair to the boiler-room operators, nor economical of fuel, to increase or diminish materially the load on the stations without giving some warning in advance. The load dispatcher should be required to furnish the boiler room with this advice as far in advance of the change as possible.

It is of almost equal importance to keep the boiler room advised of the load on the stations at all times. The best way to accomplish this is to install an indicating kilowatt meter, with an illuminated dial showing the total station load, in a conspicuous position where it can be seen from any place in the firing aisle. A meter is far preferable to an indicator that must be operated by the load dispatcher.

Water Meter and Coal Scales

Every boiler room should be equipped with coal scales or other accurate coal-weighing device and a recording water meter of some approved and reliable type. Although it would be ideal to have these instruments arranged to record coal and water for each boiler separately, this perhaps is an unnecessary refinement, if each unit has some indicator to show relative quantities. Recording steam-flow meters will provide sufficiently accurate records for apportioning the total water. If underfeed stokers are used, a stroke counter on the crankshaft will answer for the coal. Then the total weight of water can be charged to the individual boilers in proportion to their steam output, and the total weight of coal can be distributed according to stroke counters. For other types of stokers there are available various coal meters instead of stroke counters.

If a boiler room is equipped with suitable instruments, a check can be made of improvement or impairment of the efficiency of the plant as often as desired.

Draft and Pressure Gages

Certain other instruments are absolutely essential to high-grade stoker and boiler operation, and their selection depends upon whether the stoker apparatus is of a forced-draft or natural-draft type.

With stokers of the forced-draft types, each compartment of the windbox should have an individual pressure gage reading in inches of water. The range of these gages should be from 0 to about 6 inches of water for underfeed stokers. In the case of forced-blast traveling grates this range should be from 0 to about 2½ in.

There is a fairly definite relation between the air pressures in the windbox and the amount of coal burned, and a similar relation exists between the amount of water evaporated and the amount of coal burned. The boiler-room operator soon learns the relation that should exist between the flow meter and windbox pressure readings, and any variation from a standard condition is apparent at once.

Instruments to Detect Changed Conditions

With a fuel bed that is characteristic for a given stoker, fuel and load, there is a relation between the pressures in the various compartments of the windbox, and the experienced operator has no difficulty in detecting changed conditions in the furnace by observing the readings of the instruments.

Stokers of all types should be provided with draft gages over the fire. These indicate not only the variations in the draft, but also when pressure of the fire exists.

A frequent cause of high furnace and other maintenance is due to carrying a pressure, however slight, over the fire. With forced-draft stokers an effort should be made to maintain a draft in the furnace of from —0.05 in. to —0.1 in. of water. If an attempt is made to carry less than —0.05 in. draft over the fire, it is very probable that pressure will be found for considerable periods. On the other hand, if more than —0.1 in. draft is provided, the induction of cold air through the setting increases rapidly with a corresponding loss in efficiency.

Of little less importance is a draft gage located on the boiler side of the main boiler damper, but above the point of last contact of the gas and boiler-heating surface. This gage should have a range from 0 in. to 2 in. of water for natural draft, but should be increased in the case of an abnormally high stack or when induced draft is used.

Draft Loss Through Boiler

With a given percentage of CO_2 in the flue gases, the boiler having tight settings, there is a definite relation between the readings of the gage under the boiler damper and the gage over the fire for each one per cent of rating of the boiler. This is known as the draft loss through the boiler. If the CO_2 becomes low, the difference between these readings for a given rating increases. If the CO_2 increases, the draft loss correspondingly decreases. This is due to the gas volume increasing with the admission of excess air, causing the velocity to become higher with added friction, and more inertia of the gas to overcome. Conversely, an increase of CO_2 reduces the friction loss and there is less weight of gas to be carried off.

Another condition indicated by an increase in the difference between these readings is an accumulation of soot or slag on the outside surfaces of the tubes. How-

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ever, a decrease in the draft loss may mean defective baffles in the boiler. The interpretations of readings from these gages in conjunction with others is also hereinafter described.

Flue-Gas Thermometer

One of the very best indicators of the inside and outside condition of the boiler tubes is a flue-gas temperature recorder. A coating of scale on the inside of a tube and a covering of slag or soot on the outside act as heat insulators and prevent the maximum amount of heat being absorbed by the boiler. If not so absorbed, it remains as heat in the flue gas and causes an abnormally high flue-gas temperature. A high flue-gas temperature may also indicate defective baffles, or excess air from the stoker.

Abnormally low flue-gas temperatures indicate holes in the boiler settings at points beyond the furnace.

An indicating steam gage, safety valves, water gage cocks and gage glass are required by law on every boiler, and the necessity for such instruments is so well known that they will not be discussed further.

Steam-Flow Meter

One of the most valuable boiler-room instruments is a steam-flow meter. This is a great help to operators, and even the inexperienced attendant quickly learns its real value. At a glance the steam-flow meter tells which boilers are doing their work.

A furnace operating with little excess air is indicated by a high flow-meter reading, if the rate of coal feed is low and air pressure under the grates is low. High excess air is indicated by reverse conditions. Flow meters are of great value in assisting water tenders to regulate the boiler-feed water.

Steam-Temperature and Steam-Pressure Recorders

A temperature and a pressure recorder placed on the main steam header at the same point will give the steam conditions at any time, and these will be of value in making a heat balance of the boiler room.

The steam temperature recorder will also indicate when water is drawn over from the boiler to the steam main. These statements must be modified if the plant uses saturated steam. In this case the temperature recorder is unnecessary.

Feed-Water Thermometer and Feed-Water Pressure Gage

These instruments are quite necessary. The thermometer is needed principally to indicate the effectiveness of the feed-water heater and in computing a heat balance of the boiler room.

The pressure gage is necessary for safety. The operators must know that they have sufficient pressure to force the water into the boiler at all times.

CO_2 Recorders

Since CO_2 recorders have become more accurate and reliable, they have found places as standard instruments in the boiler room. They, of course, are of value to the operator for showing instantly the relative efficiency of the furnace, and are very desirable, undoubtedly justifying their expense.

Other Instruments That Should Be Provided

Numerous other devices reduce labor costs and help to build up plant efficiency, chief among which are: Feed-water regulators, balanced draft devices, and fan or damper regulators, each doing its part toward reducing operating costs. In addition there are other devices that have a more or less special field and are not to be considered as equipment to be found in the usual boiler installations.

Too much care cannot be exercised in collecting coal and ash samples. A slight error in the sampling or in analyzing may render the results useless, whereas their possible value cannot be overestimated.

Operation and Care of Instruments

The consistent use of instruments for boiler-room operation is absolutely essential if the best results are to be obtained. Most instruments are of a more or less delicate construction. They frequently need cleaning and adjustment, which can be entrusted only to one competent individual in each boiler-room who has been fully instructed in their care and use. Furthermore, definite typewritten or printed instructions should accompany each instrument and should be carefully preserved by the instrument man in the plant.

Boiler-Room Labor

Instruments alone will not reduce operating costs, but if their readings are carefully taken, recorded and intelligently analyzed, the increase in the saving made possible by their use far more than offsets their cost and operation. In addition the plant operator is contributing his share to the conservation of our most valuable natural resource, coal.

The following tabulation sums up the changes in conditions, together with the instrument readings that indicate them:

Table of Boiler Conditions Which May Be Detected by Means of Instrument Readings

Condition	Indications
1.—Thickening fire	Increase of pressure under the grates, without rise in the flow-meter reading. No appreciable change in CO_2.
2.—Thinning fire	Decrease of pressure under the grates, without decrease in flow-meter reading. No appreciable change in CO_2.
3.—Holes in fire	Decrease in pressure under the grates, decrease of draft over the fire, and decrease in the flow-meter reading. Increase in the flue temperature. Decreased CO_2.
4.—Scale inside of boiler tubes	Increase in flue temperature, without increase in draft loss through the boiler. This change is graduated over a long period, depending upon the scale-forming material in the feed water.
5.—Priming or Foaming of Water in the boiler	The water in the gage glass fluctuates up and down rapidly, sometimes with decreased temperature on steam-temperature recorder.
6.—Slag or soot on the outside of the tubes	Increase in flue temperature with an increase in the draft loss through the boilers.
7.—Holes in boiler baffles	Decreased draft loss through the boiler and increased flue temperature.
8.—Holes in boiler settings	Increased draft-loss through the boiler, usually with decreased flue temperature. Decreased CO_2.
9.—Pressure in the furnace	A positive pressure shown on the draft-gage over the fire.

Coal and Ash Handling System At the Cherry River Paper Company

By G. T. BIRCH

THE new boiler house of the Cherry River Paper Company at Richwood, West Virginia, was constructed in the fall of 1922. The labor conditions at Richwood, which is a town of about 4,000 population, are such that there is a sufficient supply of unskilled labor for the paper-mill industry, but a scarcity of skilled labor. Special attention was, therefore, paid to the type of coal-handling equipment that would require the least amount of labor, not only to operate, but to keep in condition and repair.

It was estimated that 200 tons of coal could be consumed per day of 24 hours, and any conveying or elevating system for boiler houses should handle the daily supply of coal and ash in a maximum of six hours. This would allow all material to be handled during one shift, giving the system its maximum labor-saving utility. In making the hourly capacity 60 tons, a slight leeway was provided so that ample time could be given for moving ash cans during the winter months.

The coal-storage bunker is the heart of the handling system, and the type and location of this bunker determine, to a certain extent, the layout of the coal-handling machinery. Consequently, it was logical to determine first the location, size and type of bunker to be installed. Where the steam production is very important, the bunker should have a capacity equal to at least two days' supply, giving in this case a bunker of 400 tons.

By placing the bunker external to the boiler house, the size of the latter was reduced to such an extent that a considerable saving was made in the construction. This is evidenced by the fact that there was a saving of 20 per cent in cubic contents of the boiler house as built, over that required with the bunker inside of the building and having a conveyor monitor above it.

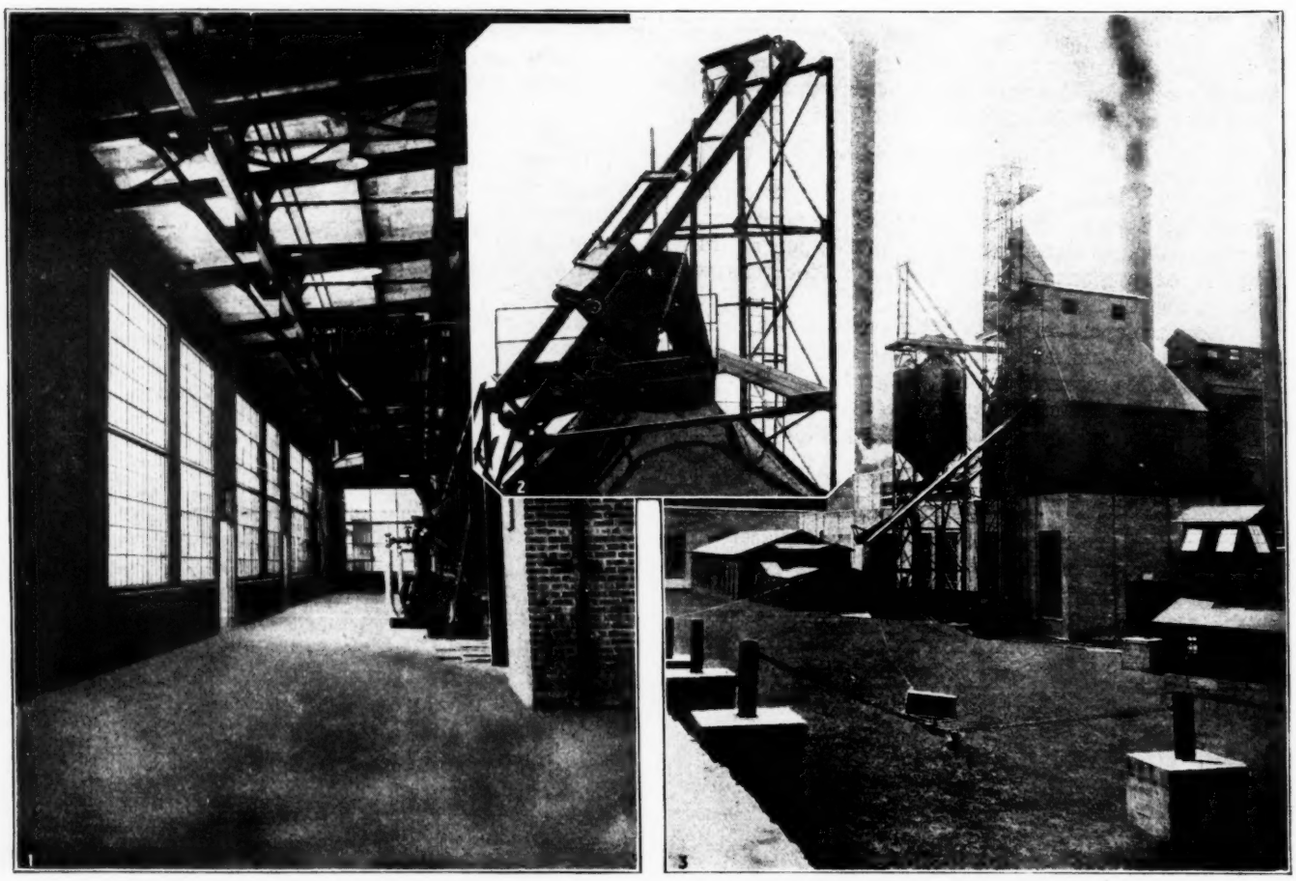


FIG. 1—VIEW OF FIRING AISLE SHOWING LOW HEADROOM DUE TO EXTERNAL BUNKERS. FIG. 2—SKIP HOIST DISCHARGING ASHES INTO HOPPER. FIG. 3—GROUND STORAGE SHOWING DRAG SCRAPER

After thorough consideration it was decided to install a skip hoist to handle the coal from the track hopper to the bunkers.

In the choice of ground-storage equipment the following points had to be taken into consideration:

1. The plot of ground available for storage, which was on the opposite side of the railroad to the boiler house, was approximately 50 ft. wide and 400 ft. long.

With a storage of 5,000 tons the depth of the coal pile would be 10 feet.

2. The amount of coal to be stored and the capacity per hour of the storage equipment.
3. The cost of the plant.
4. The cost of maintenance.
5. The cost of operation.
6. The amount of breakage to be permitted in handling the coal.
7. The length of time coal was to be kept in storage.
8. The elimination, as far as possible, of spontaneous combustion in the coal pile.

Cable Drag Scraper Chosen

The choice of coal-storage equipment lay among three or four different machines or devices, including a locomotive crane, a run-around conveyor with lower run in a tunnel under the storage pile, a monorail telpher system with a cable drag scraper. The equipment purchased was the cable drag scraper, and this machine has proved a decided success.

It was found that coal could be reclaimed as easily as it could be stored, the process being practically the same; in fact, the only change necessary was to reverse the scraper. By piling the coal in layers so that the fine coal fills the spaces between the large lumps, this type of scraper largely eliminated the fire risk.

For ash handling it was decided to use the skip hoist, collecting the ashes from the ashpits by a car, the car delivering them directly into the bucket.

Coal is received by rail and is discharged from the hopper-bottomed coal cars into the track hopper, which is 12x17 ft. in plan. From this hopper the coal is loaded automatically into the skip bucket. A spur-geared winding machine is used to hoist the bucket, which has a capacity of 60 cu.ft. The winder operates the bucket at a speed of 250 ft. per min., and is driven by a 25-hp. two-speed slip-ring motor. This motor gives a positive slowdown at the top and bottom of the lift, the speed being regulated by means of a pole-changing device on the control panel, the motor having only one winding.

Magnetic Control Automatic in Operation

The control panel consists of complete equipment for acceleration, slowdown and reverse for both directions of travel, and a limit device to operate properly the slow-down switches. Time-limit intervals are provided for discharge and loading. This control is full magnetic and automatic in operation.

The bucket, when started by pressing a push-button, ascends, discharges, reverses, descends, receives another load and continues in this cycle until stopped by the operator. A magnetic brake stops the motor when the current is broken, either by the control device or in case of failure of the electric current.

After being hoisted, the coal is discharged into a receiving hopper to which is attached a reciprocating feeder, used to feed the coal at a uniform rate to the coal crusher. This crusher, which is driven by a 20-hp. slip-ring motor, is of the double-roll type with 30x30-in. chilled-toothed rolls, and reduces the coal to 2½-in. lumps. A safety device is included to release the motor in case any foreign matter jams the rolls.

From the crusher the coal is discharged into a hopper immediately under the crusher, which is provided with a flap gate to divert the coal either to the bunker or to storage. The bunker is of the steel suspension type, the bottom plates, of catenary form, being supported by girders, which in turn are carried by the bunker columns.

Coal is drawn through the bunker gates into a 2-ton motor-driven cage-operated weigh larry. This consists of a steel-plate hopper supported from a traveling frame by scale irons. The coal is weighed and then discharged into the stokers, as needed, the stoker magazines being equipped with extension hoppers to increase their coal capacity. A ticket recorder is provided on the larry so that an accurate record can be kept of all the coal consumed and also the amount of coal burned by each boiler.

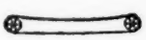
The cable drag scraper, Fig. 3, consists of a scraper attached to a cable and dragged back and forth over the storage area by means of a double-drum winding machine. This machine is driven by a 25-hp. squirrel-cage motor.

When reclaiming, the scraper is reversed on the cable so that the operation is practically the same as when storing, except that the coal is hauled into the reclaiming hopper instead of being hauled out. Around the field a number of back posts are provided to which the tail blocks are attached. The coal is reclaimed directly to the track hopper and passes through the system previously described. The winding machine is located in a woodhouse adjacent to the storage field, with the operator and one single control lever in a cabin above the house.

The ashes are collected from hoppers under the boilers by means of a car, which delivers the ashes to a 20-ft. skip bucket, similar in design to the coal hoist. Control for the ash hoist is semi-magnetic; the hoist is started like the coal skip, from a push-button station, and makes one complete cycle and then stops. It must be started again by the operator when another load is discharged into it.

The bucket operates on inclined channel tracks and discharges into a 16-ft. diameter, 4,000-cu.ft. cylindrical ash bunker, Fig. 2, at the side of the railroad, the ashes being chuted into the railroad cars.

Accurate operating costs have not been determined, but it is believed that the cost of handling the coal will not exceed two and one-half cents per ton to the bunker, or four cents per ton from the track hopper to storage, or from storage back to the bunker. All of the costs given include labor, maintenance such as renewals of cables, etc., and the interest on the money invested.



The question "Will it pay to prevent smoke?" can best be answered "it costs money to make smoke." In truth it is very expensive to make smoke, to the owner of the furnace even when not considering his neighbor. Smoke means inattention to the fuel-burning equipment in some way or another and inattention to the fuel-burning equipment causes a waste of close to one billion dollars a year in this otherwise so progressive country and that by the way is fuel waste and waste connected with fuel only. It does not take into consideration the waste due to the damage done by smoke. The waste of fuel and the waste due to the waste of fuel should, in St. Louis alone, amount to well above $10,000,000. If it were possible to quickly wake up power plant owners in this country so they would save fuel, I think we then could well cancel Europe's debt to us.—V. J. Azbe in *Forge*.

Desuperheater and Attemporator

A Special Feature of the Remodeled Batavia Electric Railroad Plant

By H. W. Brooks
Consulting and Construction Engineer

There will be installed in the remodelled power house of the Chicago, Aurora & Elgin Railroad Co. an automatic desuperheater and a manually operated attemporator for reducing the temperature of the superheated steam to the limitations of the engine portion of the prime-mover equipment. The builders of the engines did not recommend operation at higher than 500 deg. F. total temperature, while the operating condition proposed for the turbine contemplated temperatures possibly as high as 600 deg.; hence it became neccessary to design an automatic device for lowering the steam temperature before it reached the engines.

This is shown schematically in Fig. 1 and the general layout in Fig. 2. It is called upon to function automatically on steam flows varying all the way from 50,000 to 300,000 lb. per hour as the load changes, and consists of eight nozzles of graduated heavy pipe with small holes drilled in their walls, as indicated in Fig. 3. They are inserted in the top of the main steam header in a straight section of pipe just prior to the section to be desuperheated. Pads are welded on the header to permit the insertion of the nozzles. The 1-in. nozzle slips through a 2-in. double-extra-heavy pipe which is welded into the pads on the top of the header.

When the openings drilled in the nozzle for the passage of water become clogged, the nozzle may be removed without shutting steam off the header, as follows:

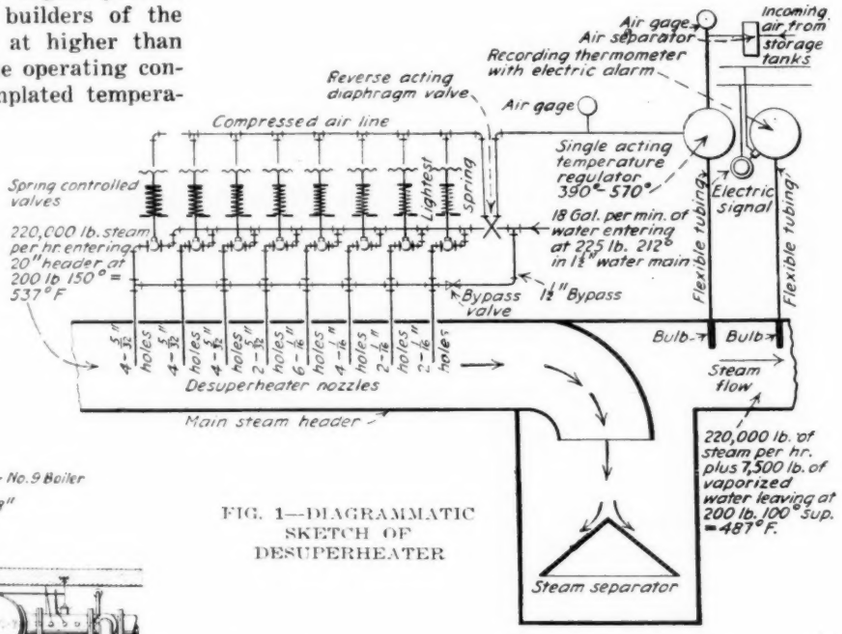

Air gage
Air separator
Incoming air from storage tanks
Recording thermometer with electric alarm
Reverse acting diaphragm valve
Air gage
Compressed air line
Single acting temperature regulator 390°-570°
Electric signal
Flexible tubing
Flexible tubing
Spring controlled valves
Lightest
Spring
18 Gal. per min. of water entering at 225 lb. 212° in 1½" water main
220,000 lb. steam per hr. entering 20" header at 200 lb 150° = 537° F
Bypass valve
1½" Bypass
Bulb
Bulb
Steam flow
Desuperheater nozzles
Main steam header
220,000 lb. of steam per hr. plus 7,500 lb. of vaporized water leaving at 200 lb. 100° sup. = 487° F.
Steam separator

FIG. 1—DIAGRAMMATIC SKETCH OF DESUPERHEATER

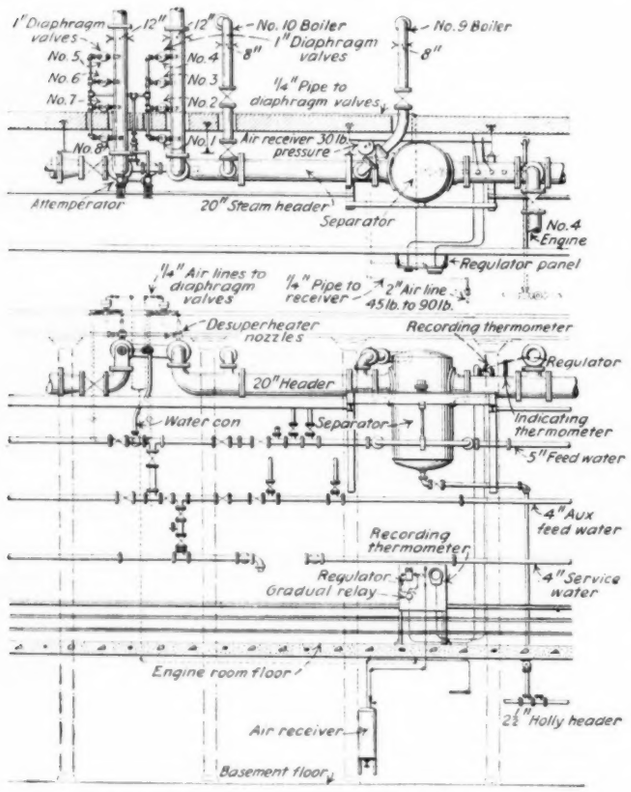


FIG. 2—RELATION OF DESUPERHEATER TO HEADER SYSTEM

sizes to accommodate more readily fluctuations of the load. Six nozzles are estimated to be sufficient to supply the theoretical amount of water required, while the seventh and eighth, which have the largest openings, act as a reserve in case of plugging of the first six.

These nozzles are machined from 1-in. double-extra-

Close the 1-in. gate valve, remove the 2x½-in. strap acting as an elbow support, unscrew the 1-in. union, pull out the 1-in. nozzle through the 2-in. pipe until the bottom end of the nozzle is above the disk of the 2-in. gate valve, close the 2-in. gate valve, unscrew the stuffing box and remove the nozzle complete. The nozzle may be reinserted by reversing the foregoing operations.

Each nozzle receives water as the quantity of steam passing necessitates, the water supply being governed by eight 1-in., reversed, high-pressure, all-metal, diaphragm-operated valves with monel seats and disks and extra-long stuffing boxes. The first of these valves is calibrated for a pressure of 2 lb. gage, the second for 3½ lb., the third for 5 lb., the fourth for 6½ lb., the fifth for 8 lb., the sixth for 9½ lb., the seventh for 11 lb. and the eighth for 12½ lb. Thus each valve opens consecutively as more and more air is admitted to the air control line by the temperature regulator. This regulator is of the direct-acting type calibrated for operating temperatures of 525 deg. high and 475 deg. low. Through the usual flexible tubing it connects to a monel bulb in a steel separable socket inserted in the main steam header just after the desuperheater. Air pressure is supplied from the main station air lines to an air-storage reservoir through a ¼-in. reducing valve lowering the air pressure on the regulator to 15 pounds.

On the diaphragm-valve side of the regulator there is a gradual relay, so that all valves will function throttling, and a needle valve for throttling the air supply to prevent hunting. A second reserve supply of air is fed into the air-storage tank from a small auxiliary air

compressor which automatically cuts in on failure of the main station air supply.

To provide a record of the desuperheated steam temperature and to act as a check on the operation of the device, a recording thermometer with high and low electric alarm functions alongside has been provided.

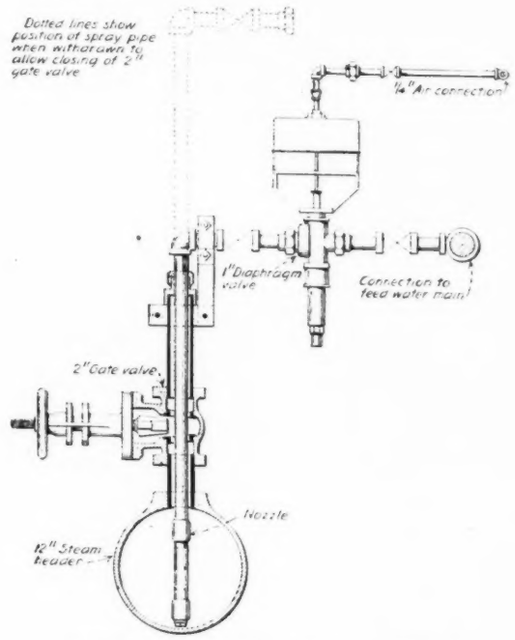

Dotted lines show position of spray pipe when withdrawn to allow closing of 2" gate valve
¼" Air connection
1" Diaphragm valve
Connection to feed water main
2" Gate valve
Nozzle
12" Steam header

FIG. 3—DESUPERHEATER IN DETAIL

The alarms sound a gong when temperatures exceed or are less than safe limits.

Just preceding the automatic device described previously, there is inserted in an elbow leading to an expansion loop, a manually operated device for the same purpose, called an attemporator. As will be noticed in Fig. 4, it consists essentially of a 1½-in., extra-heavy, cast-steel, screwed angle valve with an extended stem of monel rod and a tapered monel plug fitting into the end of a 1½-in. double-extra-heavy pipe fitted in the bottom of the angle valve. The disk of the angle valve

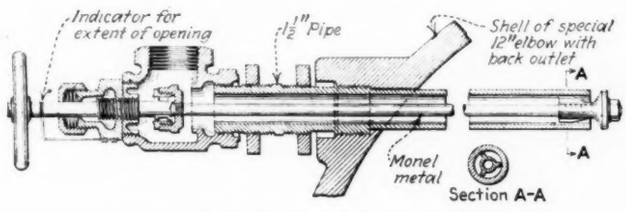


FIG. 4—DETAIL OF ATTEMPERATOR

serves no purpose whatsoever except as a medium for the monel stem to screw into, as the monel plug is so situated as to prevent its functioning. Water may thus be introduced into the header in the form of a circular sheet of any desired volume (ascertained by the temperature recorder) in case of failure of the automatic desuperheater. A chain wheel and guides permit operation from the meter panel where the temperature regulator and recorder are installed.

Following the desuperheater there is installed a special separator, Fig. 5, designed to withstand a constantly vibrating stress of 1,600 lb. vibrating ¼ in. laterally and $\frac{1}{16}$ in. vertically. Its seams were first riveted, then electric welded outside and the welds reannealed. The separator will be called on to handle a maximum of 220,000 lb. of steam per hour at 200 lb. pressure and 150 deg. superheat, or at a total temperature of 537 deg. F., and to disentrain, in addition to the water originally in the steam, any unevaporated

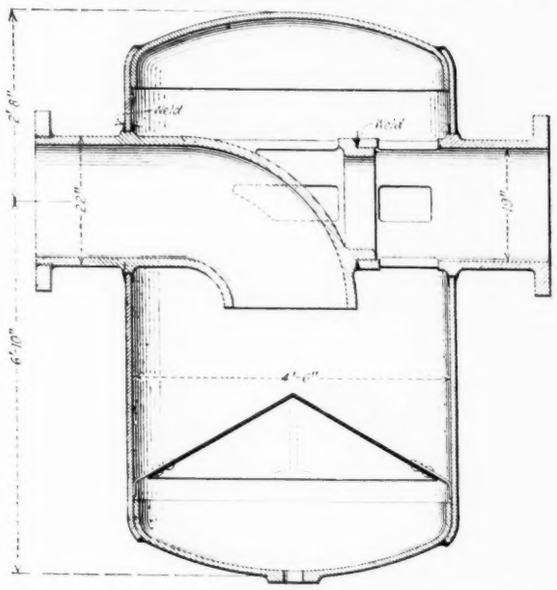


FIG. 5—SECTION THROUGH SEPARATOR OF SPECIAL DESIGN

excess from a total of 7,500 lb. of water per hour sprayed into the header in a desuperheater located approximately 20 ft. in advance of the separator.

The attemporator was developed from designs for a similar device recently introduced into one of the plants of the Interborough Rapid Transit Company of New York.

Designating Switchboard Devices

BY RALPH BROWN*

Card holders of a size bearing a certain relation to that of the switch, circuit breaker, or other device to be designated are commonly attached to vertical switchboard panels by small screws. Lettering on the cards is either printed in a press, typed, done free hand, or the card is replaced by a blueprint or photostat, a piece of clear celluloid being used to protect the printed matter. Cards printed in a printing press present the best appearance, but are likely to be expensive unless printed in quantities too great to be used in most power plants. Where designations must be frequently changed, card holders are suitable, but they tend to give a switchboard panel a cheap appearance, and the cards become soiled, especially if the panel is occasionally oiled. By keeping a supply of spare cards on hand, soiled or damaged ones can, of course, be easily replaced; however, card holders are not used on the best switchboards.

Enameled name-plates that are attached to the panel by cement are extensively used in some power plants. Such plates must generally be made to order; they present a good appearance and are durable. Name-plates of this type are to be recommended for use at all points where card holders are employed, unless the designations must be frequently changed. The appearance of

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several switchboards has been greatly improved by replacing the card holders originally provided with suitable enameled name-plates.

On benchboards and other switchboards where the best appearance is desired, metal name-plates are used. A thin copper plate with raised letters against a black background surrounded by a narrow border presents a fine appearance, and such plates are suitable for the best installations. A plain copper plate having beveled edges, with clean-cut characters ⅛-in. deep, harmonizes well with the mimic bus work found on modern switchboards. These metal name-plates are attached to the panel by small fillister-head wood screws that are screwed into lead sleeves inserted in the marble or slate. Name-plates stamped from thin tinned iron or sheet aluminum are sometimes used on switchboards, but their appearance is rarely pleasing.

As an aid to training new men and to prevent mistakes on the part of older employees, every device on a switchboard panel should be plainly designated, either by appropriate name-plates or, in the case of such devices as control switches, by their locations in the mimic bus. The purpose of a control switch forming part of a mimic bus is so clear that a name-plate is hardly necessary, the number on the panel and the name-plates on the mimic buses serving to identify the control switch.

On switchboards where the excellent plan of designating all important switches by numbers is followed, the number plate may be attached to the control switch or to the panel near it. Likewise, numbers may be stamped or engraved on the mimic disconnectors, or a number plate may be attached to the panel near each disconnector.

Any control switch that does not form part of the mimic bus should be identified by a name or number plate. All sections of the mimic bus should be designated by name-plates, as should voltmeter and synchronizing receptacles and plugs, rheostat handwheels, control switches for governor and rheostat motors, knife switches, and similar devices. On a few switchboards the letters "O" and "C," (open and close) that appear on some control switches are inlaid with white enamel, the object being to make the letters more conspicuous.

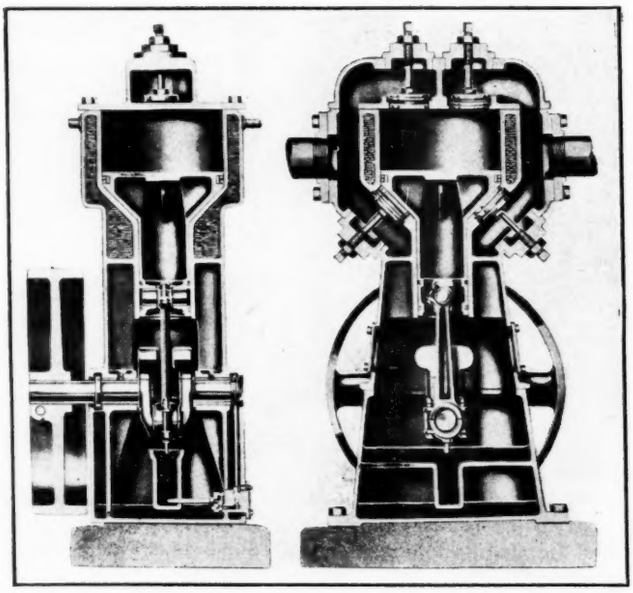
In some power plants a name-plate is attached to every switchboard instrument, relay and meter. This has been found to be a good plan, as has also the alternative of lettering the designation on the scales of those instruments and meters having sufficient space available. In one large hydro-electric plant one of the two name-plates attached to each switchboard instrument has been removed and replaced with one of identical dimensions and style indicating the designation of the instrument. This method of applying name-plates is an excellent one and is the only one that does not affect the appearance of the switchboard.

On crowded panels a simple method of making very conspicuous those instruments that may give important indications during short-circuits or grounds is to paint their cases in colors differing from the standard, which is generally dull black. Thus, in one large plant the cases of the three ammeters for each high-tension line have been painted red, while the cases of the ground ammeters that appear nearby are white. The object of this color scheme is to enable the switchboard operator to locate quickly those instruments that will give indications of faulty lines, thus helping him to correctly diagnose the nature of the trouble.

Ingersoll-Rand Small-Sized Vertical Vacuum Pumps

A small vertical pump has been added to the line of vacuum pumps manufactured by the Ingersoll-Rand Co., New York City. The pumps are made in six sizes as follows: 4x2-in., 5x3-in., 6x4-in. and 8x5-in. single-acting, and 10x5-in. and 12x6-in. double-acting. They are designed to maintain vacuums between 28.6 and 29.25 in. (referred to a 30-in. barometer) depending on their size. The four single-acting pumps are air cooled by means of an annular ring which encircles the cylinder, while the double-acting pumps are cooled by means of circulating water.

In addition to the standard belt design shown in the illustration, each size is built as a self-contained



VERTICAL DOUBLE-ACTING VACUUM PUMP

motor-driven outfit using a short belt or pinion and gear drive. In each case the pump and motor are mounted on a metal sub-base and are not dependent on the foundation for correct alignment. The general design of the pumps and arrangement of the valves is clearly shown in the illustration. The system of lubrication used, maintains a constant level of oil in a pan directly underneath the crank, into which the connecting rod dips and distributes a uniform amount of oil to the moving parts, regardless of the amount in the reservoir. The amount of oil in the reservoir is determined by high and low level pet cocks. The level in the pan is maintained by means of a pump operated by an eccentric on the mainshaft.

STEAM TABLE RESEARCH—At the recent annual meeting of the A.S.M.E., one session was devoted to steam-table research. In this session progress reports were made on the research work going on at Harvard, Massachusetts Institute of Technology and the Bureau of Standards. On account of the importance of this work *Power* will devote several articles to the subject in early issues. For this reason it was considered unnecessary to report the proceedings in the Dec. 11 issue.

EDITORIALS

F. R. LOW, EDITOR

Safeguarding Inspection Trips

A RECENT deplorable fatality on an inspection trip of electrical men through a chain of substations served by a 22,000-volt transmission tie line emphasizes anew the vital importance of taking the utmost precautions against accident when showing parties through plants. In the case in mind the victim was guiding a group of trained operating men; he was an experienced electrical engineer himself and apparently knew the dangers of high-voltage equipment as well as anyone in the party. According to the best report of what happened, he removed the cover of an oil-switch cell to show his visitors the arrangement of apparatus within, and, to emphasize the layout, pointed a finger too close to a live contact. Three hours of faithful resuscitation efforts by prone pressure and other means failed to restore life.

Mutual frendliness and understanding among operating men tends in many cases to an unwarranted assumption on the part of the visitors and of the hosts on inspection trips that all present realize the need of care in going about plants and substations. Too much trust is often placed in the visitor by the host; in other cases the guide becomes so absorbed in making details of plant design clear to his guests that he relaxes his own watchfulness and reduces the clearance between his body and live apparatus to the danger point. We have seen a man with a metal camera tripod allowed behind a high-tension bus structure; in other cases, individuals of a party have been permitted to wander about lightning-arrester banks, transformer groups and other apparatus without the close personal supervision and constant vigilance essential to safety. In these plants the general public would never be allowed to browse around for a single moment, and while trained outsiders from the operating field are entitled to many privileges, they should be taken through in small enough squads to enable one hundred per cent supervision while inside the danger zone.

What Do Furnace Repairs Cost?

FURNACE repairs are usually looked upon as a necessary evil. Because they are unavoidable, we take them as they come. How often, if at all, are furnace failures analyzed?

Because furnace repairs are all in the day's work, there is a tendency to overlook the real significance of shutdowns for repairs. We fail to appraise them at their true cost. What does it actually cost to shut down a boiler and its auxiliary equipment, repair the furnace and place the unit back into service again? A simple question about an every-day piece of routine, but it is not easily answered.

At first sight one would say, "It doesn't cost much." But when the actual cost is investigated, it will be found much more complex and much higher than appears on the surface. The cost of furnace repairs is made up of many items not ordinarily included in the total. If they were, more effort would be made to lengthen furnace life. To begin with, there are the recognized items of labor, materials and interest on the idle investment. Then there are the less obvious items of cost, more difficult to estimate, perhaps, resulting from the use of less economical units in place of the unit out of service; lower over-all efficiency due to rates of evaporation other than that ordinarily attained; less efficient load factor and loss of fuel in taking the unit out and putting it back into service again. These items can be evaluated, although they are often overlooked. They are real costs that rightfully should be charged against furnace repairs.

Then there are the items of cost that cannot be estimated. They may not occur at the time, but develop later in consequence of the furnace repairs. For example, higher combustion rates by the remaining units necessitated by the unit out of service, may cause injury to these furnaces that necessitate repairs; tubes may be damaged; slugs of water may be carried over to work havoc with turbine blades and efficiency, if nothing more. Corrosion of breechings and economizer surfaces may develop. These troubles may not show up at the time. When they eventually do, it may be difficult to charge them back where they belong. One may even fail to recognize them as a consequence rather than a cause.

When these matters are investigated, furnace repairs immediately assume a new significance. The importance of studying furnace failures becomes more obvious and the need for doing so more pressing.

Measurement of Water to Hydraulic Turbines

FOR many years a number of methods of measuring water to hydraulic turbines have been available, but most of them were difficult and expensive to apply. Fortunately, with the present high state of development in hydraulic turbines there have been devised two highly accurate and easily applied methods of measuring water in closed penstocks. As hydraulic-turbine sizes increase, the importance of measuring the water accurately increases. With the older methods these measurements became more difficult and expensive to make as the sizes of the units increased, and to make ready and conduct a test might require from a week to a month even on medium-sized units.

The two new methods—the Gibson pressure-time and the Allen salt-velocity—that have been developed during the last three years have got away from most of the difficulties experienced with the earlier methods and in addition are highly accurate, and where they are applicable at all, are as easily applied to a large unit as to a small one. As to their field of usefulness, it is too early to predict. The pressure-time method is for closed penstocks only, while the salt-velocity method may possibly in addition be used in open canals of

uniform cross-section, although development work has not been carried far enough to show what can be done under the latter conditions. There are at this time, however, no apparent difficulties in applying this method to such measurements.

An important factor is the ease with which these methods can be applied to obtain the water flowing to the turbine. The cost of the equipment or its simplicity may have small influence compared with the accuracy of the method and how much the unit's operation must be interfered with during the test. As both methods are highly accurate, their relative advantage seems to be in their ease of application, particularly in plants where taking a unit out of service means a reduction of output. With the pressure-time method the only time that the operation of the unit would be interfered with would be when taking the pressure-time diagrams, which for a complete test on a sixty thousand horsepower unit, can be done in about two hours, and during this period the turbine will be out of service only intermittently. With the salt-velocity method, although the development has been carried to a state where its accuracy has been established, future improvements should do much to simplify its application and reduce the time that the unit will be out of service when preparing to make the tests. So far as the qualifications of the personnel required to make the test are concerned, this should have little influence. If a test is worth making, it is worth being done by those who can be depended on to obtain indisputable results, and those that can, with the proper training, do this with one method can do likewise with the other. These methods can be applied to obtaining the flow at given intervals only and do not provide a means of obtaining a continuous record or indication of the quantity of water supplied to a turbine. They nevertheless represent an advance in the art of measuring water that should have a desirable influence on the construction and operation of hydro-electric plants and machinery and they have come at an opportune time.

In the Meantime Store Coal

WHAT is going to happen next spring when the present agreement between the bituminous-coal operators and miners expires is something that may well cause serious concern to those who operate steam-power plants. Some of the leaders in the bituminous-coal industry are already predicting a strike. Whether these predictions are made to stimulate the purchase of coal or are a fair warning cannot be foretold; however, one thing is sure, the agreement terminates. During the last six or seven years each time these agreements have expired the coal-mining industry has been seriously disrupted, the last expiration resulting in a five months' strike.

The problem of bringing order out of the chaos that the coal-mining industry has drifted into, with its annual strike, is not a simple one. However, it is one that affects every man, woman and child in this country and many others outside of our borders. Coal strikes have cost the nation billions of dollars in loss of production, increased costs, loss of wages to employees, disorganization of industries and transportation and excessive overhead in the coal-mining industry itself. There have been all kinds of investigations made of the industry by legislative commissions and otherwise, the buck has been passed and various schemes have been tried, but not the one that promises the greatest relief; namely, some form of government regulation. State regulation of public utilities has been successful when properly applied.

This is a question that will be brought up before the present Congress for action, and it is predicted that included with the first bills to be presented before both houses there will be a number for the regulation of the coal industry. Of course it is one thing to get these bills introduced and an entirely different thing to get constructive laws passed. Even if such laws were passed, there arises the question of federal regulation, since the Supreme Court has decided that the mining of coal is intrastate and not interstate business. This being the case, some remedy for this difficulty must be found either in a treaty among states, as suggested by Governor Pinchot in his plan for regulating the anthracite industry, or an amendment to the Federal constitution or some other scheme. State rights cannot forever subordinate the interests of the nation when the upholding of these rights results in the hardships that an unregulated coal industry has brought. What will happen to prevent a cessation of mining, between now and next spring when the present agreement between the bituminous miners and operators expires, cannot be foretold. In the meantime it will be wise to store coal in anticipation of the worst that might occur.

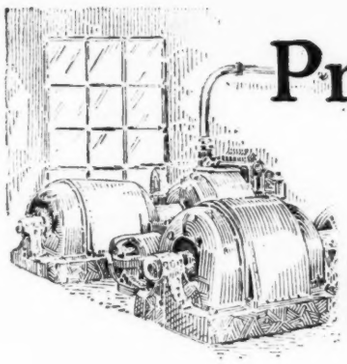
Always Another Way

UNLESS one wants to go down in history as a poor prophet, it is necessary to use extreme caution in saying "It can't be done." All this phrase usually means is that, within the limited range of the speaker's vision, he can see no practical means of accomplishment. In this connection the heat-cycle papers and the discussion presented at the recent annual meeting of the A. S. M. E. hold food for thought.

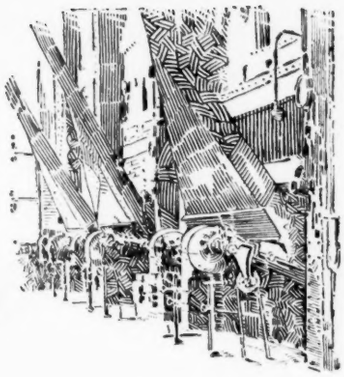
For years steam engineers have looked upon the Rankine cycle as the "practical ideal," considering the Carnot and other equally efficient cycles as of purely theoretical interest. Recently, attention has been directed to the regenerative cycle, which (in its limit) is as good as the Carnot.

With the disappearance of the Rankine cycle as an ultimate objective, came another self-imposed limitation. It was assumed at once that feed heating by bled steam, which is the distinguishing feature of the regenerative cycle, could not be carried up into the superheated region. With high initial superheat, and particularly with reheating, this greatly restricted the practicable range of extraction. In the discussion at the heat-cycle session the logic of this limitation was questioned. Certainly, this is a matter that should not be passed over without investigation.

Again, it has been taken for granted that the heating of feed water by steam bled from the higher turbine stages must drive out the economizer. Yet one author of a paper showed that bleeding might be used right up to the boiler pressure without displacing the economizer. This seemingly impossible result could be obtained by dividing the feed water into two portions, one heated by bled steam and then bypassed around the economizer to the boiler, and the other passed through the bleeder heaters of the lower stages only and then to the economizer. In such a plant still other portions of the bled steam might be used to preheat the furnace air. This scheme is presented not as a necessarily desirable practice, but as still another proof that "there is more than one way to skin a cat."



Practical Ideas *from* Practical Men



Retubing Boilers with Bulged Heads

Recently, we found it necessary to retube several return-tubular boilers, and it occurred to me that the methods we used in straightening the bulged head might be of interest to other readers.

In Fig. 1 is shown the common type of return-tubular boiler. The tubes are cut out with a chisel by chipping off the beads and splitting the tubes on one side and hammering the end in toward the center to free it on the tube sheet. If the tubes are reasonably free of scale, they can then be pulled out through the tube hole. Another method used was to cut the tubes off just inside the head and remove them through the handhole at

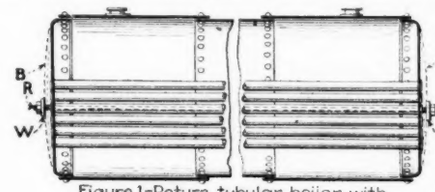


Figure 1-Return tubular boiler with bulged heads

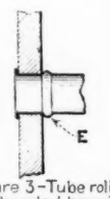


Figure 3-Tube rolled and beaded heavily to hold warped tube sheet

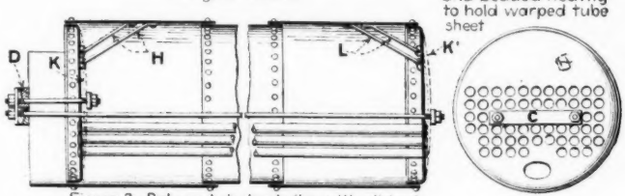


Figure 2-Return tubular boiler with dished front head and bulged rear head

FIGS. 1-3—METHODS USED IN STRAIGHTENING HEADS WHEN RETUBING THE BOILER

the bottom of the drum, the beaded thimbles being cut out after all the tubes were removed.

The new tubes were made the same length as the old ones, measured near the shell, and they were all made ready, as also were the tools, before the boilers were shut down.

When the tubes were all removed, the shell and heads were cleaned thoroughly and the heads examined for corrosion. A few tubes were then put in place to see if they were the proper length, and with the aid of a straight-edge we examined the heads for warping or bulging. Usually, any bulging in the heads is not visible without employing a straight-edge, but $\frac{3}{8}$ or $\frac{1}{2}$ in. on each head is sufficient to make the standard length of tube too short for the central portion of the head. Of course longer tubes could be used, but it is advisable to keep the heads flat and the stresses as even as possible by having all the tubes the same length.

If the heads should be found to be slightly warped, as shown (exaggerated) by the dotted line in Fig. 1, they can be drawn in readily by placing a bar *W* across each head and using one or more through draw-bolts *R*. After a few tubes have been put in place, the draw-bolts can be removed.

Fig. 2 shows a boiler with the front head *K* dished inward and the rear head *K'* bulged outward, as indicated by the dotted lines. To draw the heads back into place, the timber *D* was placed across the extension of the boiler shell and draw-bolts were run through it to an iron bar placed inside the head. The rear head was straightened by using a long draw-bolt as in Fig. 1. Another timber was placed across the front of the boiler and the bar *C* across the rear head, as shown in the end view of the boiler.

As the tubes were put in place, they were rolled to give a heavy ring *E* inside the tube sheet, as shown in Fig. 3. The beading on the outside was also made a little heavier than is usually done.

After the tubes were all put in place, the braces *H* and *L* which had been removed previous to straightening the head, were again put in or replaced with new ones. Care should be exercised when doing this to have all the braces exactly the proper length, so that no undue stress will be exerted.

Bulging and warping of boiler heads may be brought about in several ways, such as careless workmanship when putting in tubes, overheated tubes caused from excessive scale accumulation in the boiler, distortion of the shell in process of flanging or punching the tube holes, and improper bracing.

After the tubes are all rolled and beaded, the boiler should be given a hydrostatic test and carefully examined for leaks around the tubes before being put in service.

R. A. CULTRA.

Cambridge, Mass.

Large Saving in Process Steam Effected by Reducing the Pressure

Some time ago, in an attempt to prove that low-pressure steam could be used advantageously on certain types of machines used in our industry, I conducted several steam-consumption tests in combination with efficiency tests.

The results of the test showed very clearly that it was possible to use a pressure of three to eight pounds instead of the twenty or thirty that the operative had been using for about ten years. Not only was the consumption of steam reduced in proportion to the amount of work done, but the danger to the workers from the bursting hazard of the machine was reduced.

During the tests the operative was carefully instructed about the improvements, and when they were finished he seemed to understand thoroughly that the work could be done with the lower pressure. The habit of the past years was too firmly rooted, however, to be changed so quickly, and we found that he was soon back in the old rut. Repeated "callings" had little effect except when there happened to be someone around to watch.

He was allowed to go on for some time until the waste was so evident that we determined to stop it once and for all. The day chosen was a dark one, and when he was given the little talk about the steam being at fifteen instead of five pounds he responded, "Yes, but it takes twice as much steam to dry on a dark day as on a bright one." Another, who was standing by, contributed his sentiments with this, "That's right Joe, but you're using three times as much."

We haven't decided to start a class in thermodynamics for the education of operators doing that class of work, but do agree that there is room for education on steam.

H. A. POOLE.

Wappingers Falls, N. Y.

Changing Induction Motor Winding To Operate on Reduced Voltage

We had an induction motor rated at 220-volt, 1,155,-r.p.m., 40-hp. three-phase, 60 cycles. There were 72 coils in the stator, and each coil had 8 turns of No. 12 and 8 turns of No. 13 wire, the two wound in parallel,

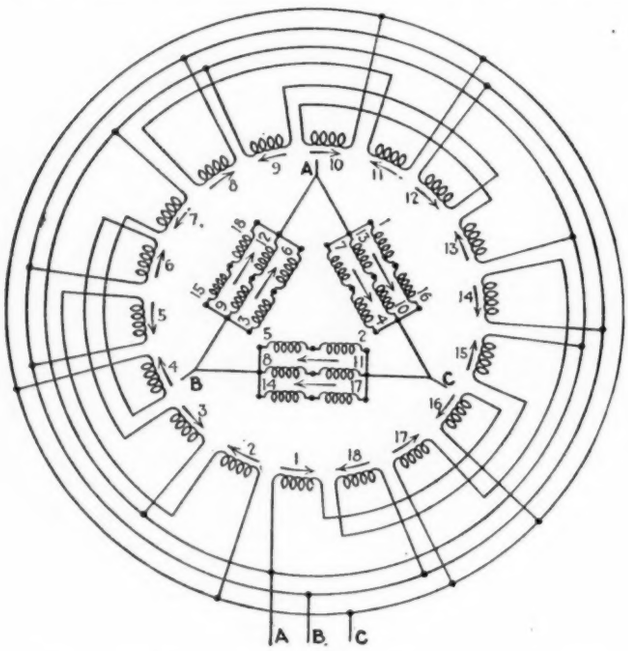


FIG. 1—SIX-POLE INDUCTION-MOTOR WINDING CONNECTED THREE-PARALLEL DELTA

and the coils connected 3-circuit delta for 6 poles, Fig. 1. The motor would not develop full rated horsepower on account of the voltage being about 190 to 200 volts. Since conditions were such that the possibilities of improving the voltage were not very promising, it was decided to try to make some change in the motor connections that would make the winding suitable for operation on the lower voltage.

The original winding was connected 3-parallel delta and was good for 220 volts. If this winding were connected 6-parallel delta it would be good for one-half of 220, or 110 volts. Changing the connections to 6-parallel star would make the winding good for $110 \times 1.732 = 190$ volts, which was the desired voltage. This made the solution of the problem comparatively simple,

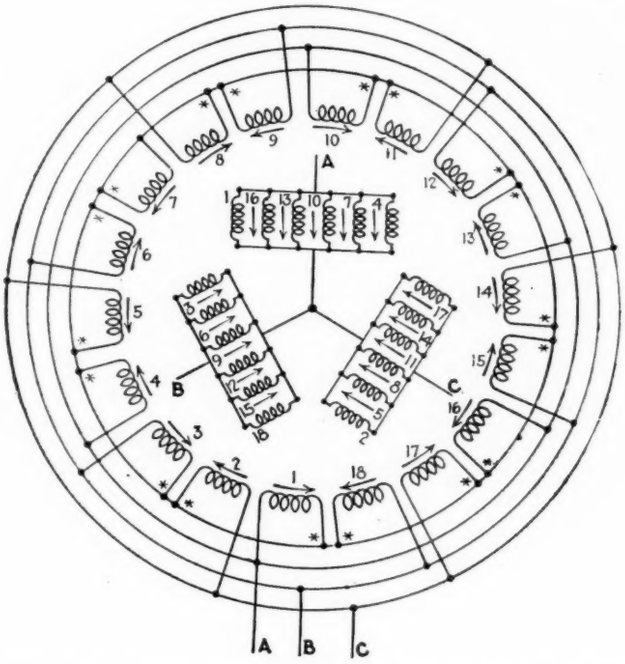


FIG. 2—WINDING, FIG. 1, GROUPED SIX-PARALLEL STAR

and since the change was made the motor has carried its load without difficulty.

It might be added that where the winding cannot be regrouped to meet a change in voltage, the pitch of the coils can be changed, but this will require lifting the top side of the coils out of the slots, which is not desirable, if there is some other way of accomplishing the same end without excessive expense. The maximum change in voltage that can be accomplished by a change in coil pitch is 30 per cent, which corresponds to changing from full to 50 per cent pitch. Since most windings have the coils spread less than full pitch, the change in voltage possible by changing the pitch of the coils will be less than 30 per cent.

A. A. FREDERICKS.

Philadelphia, Pa.

Brass Fittings in Refrigerating Plants

Many refrigerating-plant engineers have an idea that brass valves or fittings cannot be used on ammonia lines under any circumstances. This is a mistake because they will stand up for a considerable length of time in this service before showing any signs of distress, although of course no one would recommend their use except in emergencies.

The oiler in a plant where I was operating broke the stem of one of the valves in the oil line leading to the stuffing box on one of the ammonia compressors. The packing in the stuffing box was old and hard and as soon as we attempted to run the machine without oiling the stuffing box, the rod would either run smoking hot or would leak so we could smell it all over the place.

There was not another valve of the size required, to be found around the place. For want of something better I made use of a half-inch extra-heavy brass globe valve. This served the purpose for nearly a month until an ammonia valve was secured from the factory. When removed the brass valve did not show any signs of corrosion and was later placed in a low pressure steam line, where it continued to give good service.

At one time I had to connect a branch connection into a liquid line already in service. The whole line was made up with screwed fittings, so I cut the old line in two with a hack saw between the two tees, and proceeded to fit in the tee for the new branch. A flanged coupling was not to be found around the plant, except those that were already in service, so I decided to use the regular type of union.

In one of the high-pressure steam lines we found an extra-heavy brass union of the required size. A common box union was installed in its place, and the final connection in the liquid line was made with the brass union. This union showed signs of pitting and had been more or less corroded by the ammonia, but not enough to make it dangerous. After it was taken out, it was tested to 800 lb. hydraulic pressure, but failed to show any signs of weakness. The reason the union showed more corrosion than the valve previously mentioned, was probably due to the oil film in the valve, which gave it considerable protection.

J. C. LAMBERT.

Chicago, Ill.

Failure of 20,000-kva. Generator

In a power plant where I was recently employed, a 20,000-kva. waterwheel generator failed while fully loaded, owing to a splice between adjacent field coils burning apart. A slight instantaneous decrease in the generator-bus voltage gave the first indication of the impending failure of the field circuit, and before the operator could diagnose the trouble from the switchboard instruments, the generator-bus and exciter-bus voltages had become very low. During the few seconds required for the generator-bus voltage to decrease to zero, the following events occurred, apparently in the sequence indicated:

The connection between the field coils burned apart, opening the field circuit and grounding one field coil.

The connection to the upper main contact in the voltage regulator burned apart.

The regulator's direct-current magnet coil burned out.

Voltage from the exciter bus entered the 125-volt control wiring at two points.

The 125-volt control-bus ground lamps exploded.

One exciter brush arm became grounded.

The contact arm on the generator-field rheostat became badly overheated.

It is a well-known fact that when current flowing through a highly inductive circuit, such as a generator-field winding, is suddenly interrupted, a high voltage is induced in that winding, due to the rapid collapse of the magnetic lines of force. In this case it appears that the crest value of the induced voltage applied to the exciter bus exceeded 1,000 volts, since the induced voltage broke down a $\frac{3}{32}$-in. air gap in its path to the 125-volt control wiring, thence to earth.

The high voltage applied to the regulator's direct-current magnet coil caused an arc to become established between the outer layer of wire and the magnet yoke, which was electrically connected, through pivot bearings and a small flexible conductor, to the positive control bus. The storage battery in parallel with the control buses permitted the high voltage that was applied to the positive bus to flow to the negative bus, and the ground lamps exploded because of the abnormal current that was forced to earth through them by this high voltage.

Sufficient current passed through the main-contact flexible lead to melt it, and this caused all the regulator contacts to remain open. The opening of these contacts inserted maximum resistance in the exciter shunt-field circuit and caused the exciter voltage to be rapidly decreased. Since one exciter supplied all the generator fields, the generator bus voltage also decreased to zero, and this would have occurred, because of the damaged regulator, even if the faulty unit had been quickly cut out.

OTHER EVENTS IN THE FAILURE

The high voltage applied to the frame of a small auxiliary switch electrically connected through a supporting bolt to the exciter equalizer circuit breaker jumped a $\frac{3}{32}$-in. air gap, entering the control wiring at this point, and flowed to the positive control bus, thence to earth through the ground lamps. A No. 16 copper wire forming part of the auxiliary switch operated by the exciter negative circuit breaker was melted by the current flowing from the equalizer circuit-breaker auxiliary switch. The failure of this wire made it impossible to open either the negative or equalizer circuit breakers from the benchboard.

A few switch-indicating lamps on the benchboard were burned out because of the high voltage applied to the control bus.

An arc was established between one brush arm on the exciter and the grounded frame, and as one of the generator field coils had become grounded when the splice burned apart, current flowed from the exciter frame to the generator rotor, thence to the grounded end of the field winding. Leaving one collector ring, this current passed through the generator field rheostat before returning to the ungrounded side of the exciter. As only a few field coils of low resistance were included in this grounded circuit, a heavy current flowed and, passing through the exciter series winding, tended to maintain the exciter voltage, although all the shunt-field rheostat was cut in by the regulator. This abnormal current caused the generator field-rheostat arm to become overheated.

Although it was possible to repair the damaged field coil in the station, considerable time was saved by using a spare coil and core, and the advantage of keeping such spare parts on hand was clearly indicated.

The fact that the generator is completely inclosed makes inspections difficult and expensive, yet the practice of making thorough inspections and cleaning the windings at intervals of six months has been followed since the units were placed in service. An inspection requirement is that with the rotor at rest and maximum field current applied, no field splice shall be unduly warm when felt by the hand. Since no evidence of heating had ever been detected when inspections were made, this field failure occurred without warning, and a careful examination since made of all of the other field splices has disclosed no signs of other than normal temperatures.

A. M. BEARD.

Philadelphia, Pa.

Comments from Readers

Are All Power-Plant Designs Justified

There is going on in the field of power development, public-utility service and industrial plants today, design work that sometimes effects the most economical results from a financial viewpoint. This is due, in some cases, to lack of information, to ignorance of the engineering profession, to ignorance of what is involved in the way of capital outlay and returns on the investment, and in some cases to a desire to install a modern plant to gain supposedly more economical results. A competent engineer, giving deep thought to the design, can produce results, while an incompetent engineer will design to produce errors that can never be eradicated. It is quite easy to design and erect a plant or install new apparatus, but the principal object is to have such designs show economy and a financial return. It is not easy to define any standard layout for any type of plant. Each must be made a study in itself. In a number of cases, not enough thought is given before the changes are made and the loser is the owner of the plant. The engineer does not lose financially. If mistakes are continued, however, the engineer loses his prestige and brings discredit to the engineering profession. It should be an object of pride to design a plant so that it will meet results as originally figured and without any unnecessary expense. This will keep up the high standard of the profession which each engineer should strive to maintain.

Before any changes are made in an existing plant, it must be known how to operate the existing equipment at the lowest possible cost for the required service and also how the present costs can be reduced or services be improved by the addition of new equipment or devices or alterations in the present arrangement of the plant. The initial costs must be known as well as the returns they will give on the investment. It is not so much a question of thermal efficiency, increased ratings, reduced steam or power consumption, as it is a question of actual reduction in the total operating costs after all charges are paid. Money costs money just as truly as does coal, labor or any other of the power-plant supplies. The cost of new money must therefore, be figured in the recommendations for improvements. It is often found that supposed improvements have actually increased the total costs when the fixed charges, maintenance and other items have been added to the operating charges. The final test is how much will it reduce the total costs and what will be the return on the investment? In other words, how much money will it make? No changes should be made unless this can be definitely established, and in numbers of cases this has not been done, involving financial loss instead of gain. There should be a business question involved as well as a designing proposition in each change.

There is a tendency on the part of some industrial executives to look with disfavor on revamping an old plant. What they desire is a new one with some new boilers and all the modern apparatus that goes with them. But there are many old plants that can be made into fine, efficient properties with far less outlay than a new plant would cost and in the end will produce steam just as cheaply. Sometimes, upon making a survey of an old plant, certain consulting engineers will make a report calling for a new plant and abandoning the old one. This may sound very inviting for an owner who has plenty of money to invest on which he does not look for liberal returns. In a good many cases owners act too quickly on some recommendations involving extensive investments and changes in their power plants, anticipating big savings in fuel, labor, etc., but are finally disappointed in the results obtained. Engineering questions of importance are sometimes decided without even getting the opinion of men long trained in their specific work. In some cases expert opinion is received and then disregarded. All the facts in any case should be brought out, and no design or recommendations should be made to meet any other condition than that of furnishing the best engineering proposition for the particular case. Often exaggerated ideas are given to owners of power plants as to what can be done to improve the net earnings by suggestions that are ideal and not practical. Almost anyone can go into an average plant and make suggestions that will give economy in operation, but there is always the question whether the improvements will show a net gain in the long run when everything is taken into consideration. The real task is to differentiate between improvements that apparently show a gain but do not and those that do. Some manufacturers, after improvements are made, do not know whether any financial gain has been produced by the change.

The question as to whether a manufacturer should purchase current is not easy to answer in some cases. No one should be guided solely by the sales efforts from central stations. In some cases such decisions are made without due study and the results are financial loss. There are many cases where plants should use purchased power, and in others it has no place. Where byproduct heat is used, all the power available for the manufacturing purposes should be made from this. Failure to do this is not only a great economic loss in a plant, but it is also responsible for a direct financial loss. The facts about byproduct power are relatively simple and easily understood, yet the money wasted each year by lack of knowledge on this subject amounts to considerable. In many cases it would be advisable to have a reciprocal agreement to give or take current where the use of byproduct heat is variable. Various possible combinations must be compared in the light of the conditions actually existing in the given plant. The investigations should be made by a trained man who understands steam from the ground up and who knows how to figure costs. Such a man may easily save thousands of dollars each year.

Hydro developments must show returns on the investment. In many development cases, large invest-

ments are required. The interest on this plus maintenance, operation and depreciation charges represents the cost of the power and is just as tangible a cost as that of a coal-fired plant. The cost of either is represented in the expense of making the power available, and the cost of the kilowatts produced by the water-power plant may be equal to, or even higher than, the coal-fired plant. Sufficient previous studies should be made of such developments before any decision is made.

There is nothing that will so discredit the engineering profession as to have mistakes creep in which are at the expense of an industry. This is especially true where extensive changes are made to bring financial returns. Anyone, regardless of his qualifications or experience, can lay out plants or advise on engineering questions provided he can obtain clients. Under these conditions mistakes and errors of judgment are bound to creep in. All those who are engaged in engineering work should strive, regardless of personal gain, to make the best possible decision and design on any engineering question in which they are engaged, and it behooves the industrial executive to use his best judgment in engaging the engineer that is best qualified to fulfill the work he desires. This will, in the long run, raise the standard of the engineering profession as well as give the best satisfaction to the client.

W. G. DIMAN, Supt. of Power,
Manchester, N. H. Amoskeag Manufacturing Co

What Happens to Moisture When It Enters the Furnace?

I have noticed the question by R. McLaren in the Sept. 18 issue and also by J. F. Edgell in the Nov. 6 issue, and I will endeavor to explain what may take place.

Mr. McLaren's difficulty is that he has confused the dissociation of steam with its decomposition by hot coal or hot iron. By dissociation we understand the breaking up of a substance into its free elements or constituents. Steam, when heated alone, is dissociated into hydrogen and oxygen. Brought in contact with iron turnings in a tube of 1,000 deg. F., for example, it is not dissociated, but the oxygen combines with the iron, forming the magnetic oxide and leaving hydrogen free (Millar), the formula being as follows:

$$4H_2O + 3Fe = Fe_3O_4 + 4H_2$$

Steam + iron = magnetic oxide + hydrogen

(This shows what takes place).

Likewise, when steam is brought into contact with incandescent carbon (hot coal) at 1,112 deg. F., it combines with the carbon, forming carbon monoxide CO, and carbon dioxide CO_2, and hydrogen is again left free (H. S. B. W. Cochrane Corp.) or expressed in a formula,

$$H_2O + C = CO + H_2 \text{ and}$$

Steam + coal = carbon monoxide + hydrogen

$$2H_2O + C = CO_2 + 2H_2$$

Steam + coal = carbon dioxide + hydrogen

Mr. McLaren quotes from Jos. W. Hays, who is undoubtedly right when he says, "The first thing that happens is the evaporation of the surface moisture clinging to the coal." This probably also is the main thing that happens. Mr. Hays, however, is wrong when he says that "the resulting steam is decomposed into its elements, hydrogen and oxygen." It is highly improbable that any is so decomposed, for it has been shown that practically no steam is dissociated into its elements below 2,900 deg. F. Inasmuch as this temperature is not commonly reached in the boiler furnace (for even the wrought-iron grates would melt), it is safe to say that no steam is dissociated. Note, however, that steam heated by itself is here spoken of and not with coal or hot iron.

An altogether different state of affairs takes place when steam comes in contact with hot coal or carbon. Then it generates hydrogen and carbon monoxide, also carbon dioxide. As J. Bunte, of "Gas Lighting," Vol. 53, page 481, and Edgell, in the Nov. 6, 1923, issue of *Power* have shown, this begins at about 1,112 deg. F. (600 deg. C.) and reaches a maximum at about 2,057 deg. F. (1,125 deg. C.). Inasmuch as a deep fuel bed and abundance of steam are required for such decomposition, the quantity of these gases formed in the ordinary boiler furnace would be very small: they would immediately take fire and burn (except the carbonic acid), giving up the same amount of heat that was used up in their formation, plus the heat of combustion of the carbon to carbon monoxide, so there would be only the latter gained.

Finally, if moisture comes in contact with unrusted iron at a temperature of about 1,000 deg. F., it is conceivable that the iron might be rusted by the oxygen of the water, and hydrogen freed. Rusty iron would be unaffected.

Discussing some of the questions raised, the following may be said:

Regarding the ignition temperature of hydrogen, Dixon & Coward (Proc. London Chem. Soc., Vol. 26, page 67) give the temperature as 1,085 deg. F., which is not so far from that of 1,130 deg. F. given by A. D. Pratt. Inasmuch as it has been stated (by Gill, *Power*, Jan. 28, 1913) that steam is decomposed at a temperature of 1,912 deg. F. to the extent of 0.0086 per cent and at 2,900 deg. F. only to the extent of 0.3 per cent, a higher temperature being necessary to seriously decompose it, it would seem that Deville was right when he said at 1,760 deg. F. (960 deg. C.) it was decomposed (really dissociated) to a limited extent; how limited he probably did not realize.

When R. E. Millar states that he has made thousands of cubic feet of hydrogen with steam at a temperature of 1,000 deg. F., Mr. McLaren overlooked the fact (or did not state it) that it was heated in connection with iron, which is, as has been said, quite a different matter from heating it by itself and really breaking it down into its elements. This will account for the difference in temperatures. This is also true of a later paragraph, in which Mr. McLaren speaks of "dissociation temperatures" of 1,000 deg. F. and 1,112 deg. F.

In the Oct. 16 issue T. A. Marsh says that moisture is an advantage with coals from west of Pittsburgh and not with those east of that city. Further, moistening coal decreases the sifting through the grates, causes fewer holes in the coal bed, gives a higher combustion rate, produces an improved quality of ash, and with traveling grates, gives better ignition. To volatilize 3 per cent of moisture 0.3 per cent of the heat is required.

Summing the matter up, moisture in the furnace: First, evaporates almost completely; second, any left is changed by hot coal to hydrogen, carbon monoxide and dioxide; or, third, coming in contact with hot iron may form hydrogen and magnetic oxide of iron (which is very unlikely); fourth, is *not* decomposed into hydrogen and oxygen.

A. H. GILL.
Cambridge, Mass.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Efficiency of Boiler Joint

On what does the efficiency of a boiler joint depend?

R. G.

The efficiency of any joint is the ratio of its strength per repeating section to that of an equal length of solid plate. This ratio usually is expressed in per cent. The strength per repeating section depends on the strength of solid plate or of straps, after removing material for rivet holes, or the shearing strength of the rivets, or the combined strength of remaining plate and rivets, considered with reference to the least strength in any method of failure of the joint.

Pressure at Bottom of Mud Drum

The distance from the water level to the bottom of the mud drum of our boiler is 10 ft. and the steam pressure carried is 150 lb. gage. What is the pressure per square inch on the bottom of the mud drum?

F. F. N.

The pressure at any point below the water line is equal to the steam pressure at water line, plus the pressure due to the head of the water. The temperature of the boiler water when the steam pressure is 150 lb. gage is 366 deg. F., and at that temperature the weight of water is 54.94 lb. per cu.ft., hence for 10 ft. head above the bottom of the mud drum, the pressure per square inch due to the water alone would be $\frac{54.94}{144} \times 10 = 3.82$ lb. per sq.in. If the center of the steam gage is level with the water line of the boiler and water in the steam gage siphon is level with the water line of the boiler, a correct pressure gage would indicate the pressure of steam at the surface of the water. Hence if the gage indicated 150 lb., the pressure on the bottom of the mud drum would be $150 + 3.82 = 153.82$ lb. per sq.in. gage pressure.

Actual Ratio of Expansion in Compound Engine

A compound engine has a 14-in. diameter high-pressure cylinder, 30-in. diameter low-pressure cylinder, each with 36-in. stroke, and each cylinder has 5 per cent clearance. If cutoff ocurs at one-third stroke of the high-pressure cylinder, what is the total ratio of expansion?

J. A.

The ratio of expansion, or number of expansions, is the total volume of the low-pressure cylinder and its clearance volume, divided by the total volume of steam in the high-pressure cylinder at the time that cutoff takes place.

If the low-pressure cylinder is 30 in. in diameter, 36-in. stroke, and has 5 per cent clearance volume, then the cylinder and 5 per cent clearance would have a total volume of $(30 \times 30 \times 0.7854 \times 36) \times 1.05$ cu.in.

The total volume of steam in the high-pressure cylinder when cutoff occurs at one-third stroke would be 5 per cent plus $\frac{1}{3}$ of the piston displacement per stroke, or $(14 \times 14 \times 0.7854 \times 36) \times (0.05 + \frac{1}{3})$ cu.in.

Therefore the ratio of expansion would be

$$\frac{(30 \times 30 \times 0.7854) \times 36 \times 1.05}{(14 \times 14 \times 0.7854) \times 36 \times (0.05 + \frac{1}{3})} = \frac{30^2 \times 1.05}{14^2 \times (0.05 + \frac{1}{3})} = 12.58$$

From the foregoing it may be seen that the actual ratio of expansion is equal to the square of the diameter of the low-pressure cylinder multiplied by 1 plus the fraction of clearance, divided by the square of the diameter of the high-pressure cylinder when multiplied by its fraction of clearance plus the fraction of cutoff in the high-pressure cylinder.

Feeding Evaporating Coils at Top or Bottom

Is it better to feed into the top or the bottom of ice-tank coils? In the layout I have in mind, the ice tank has sixty-four 200-lb. cans, 1,100 ft. of 1¼ pipe which is split in two sections, 550 ft. to each expansion valve. I have understood that feeding in at top causes quicker evaporation of ammonia and there is less liquid ammonia coming back to the machine; also that less ammonia is needed to charge the system.

L. C. H.

Feeding ammonia from the top will produce a quicker evaporation of ammonia; that is, ammonia will be evaporated before it passes through as much length of coil as it would be if fed in from the bottom. However, it should be remembered that to produce a given amount of refrigeration requires the evaporation of a certain amount of ammonia regardless of whether it is fed from the top or bottom. If the feed is from the top and there is enough coil surface so the ammonia evaporates before it passes through more than half of the length of the coil, it is to be expected that during its passage through the lower half of the coil it will continue to pick up a slight amount of heat and be superheated before it reaches the compressor. This superheat will be very small in order to carry a low temperature in the ice tank but, in effect, only half of the coil is used for evaporating purposes and the other half is practically idle and of no value. It follows then, that with a system of feeding the ammonia at the bottom of the coil rather than the top, the total amount of coil surface in a brine tank can be considerably less than with the top feed.

Undoubtedly, there is less chance for the liquid to be pulled over the ammonia with the top feed, but if the expansion cocks are regulated in accordance with the load on the brine tank, there is no reason why the ammonia should not leave the tank practically dry saturated. Undoubtedly, in passing along the suction

line to the compressor it will pick up a few degrees of superheat sufficient to dry out the suction vapor and prevent any flooding or damage to the compressor due to excessive amounts of liquid. A slight amount of liquid is of no serious disadvantage to the machine, since it will all evaporate as it passes through the compressor and suction valves, and really assists in keeping the suction valves cold. On the other hand, there is a slight increase in the amount of horsepower per ton of refrigeration with the wet compression.

Of course, a flooded system will require somewhat more ammonia than will the top feed system, but if the pipe layout is tight, there is no reason why you should lose any of this ammonia, or lose any great amount of it. Consequently, while the initial investment is slightly higher, the renewal of the ammonia will be no greater than it will be with any other system of feeding.

Calculating Horsepower Output to Alternating-Current Motors

What formula is used for determining the horsepower input to alternating-current motors, knowing the voltage and amperage, if the plant's power factor is 1.00, 0.90, 0.80 or 0.70? T. P. L.

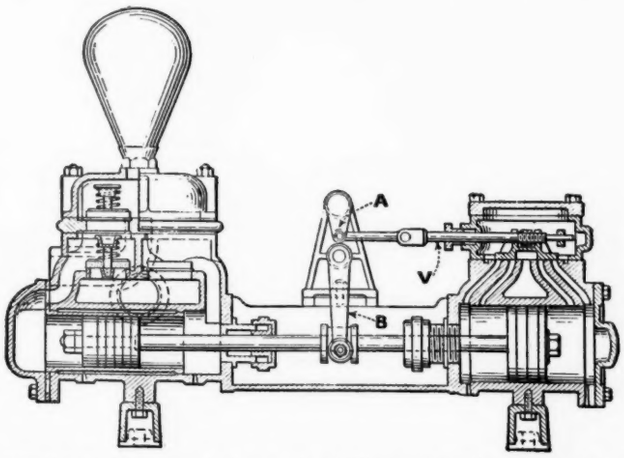
Unless the entire load is made up of motors, the plant power factor is not the resultant power factor of the motor load, therefore could not be used to calculate the power input to the motors. On a single-phase circuit the horsepower input to a motor is equal to volts times amperes times the power factor divided by 746. For example, if a single-phase motor is taking 50 amperes at a power factor of 0.80 or a 220-volt circuit, the horsepower input will equal $(220 \times 50 \times 0.80) \div 746 = 11.8$. On a two-phase circuit the horsepower input equals 2 times the volts of one phase times the current of one phase times the power factor divided by 746. Assuming the same values for the two-phase motor as for the single-phase, the horsepower input equals $(2 \times 220 \times 50 \times 0.80) \div 746 = 23.6$ The electrical horsepower input to a three-phase motor equals 1.732 times the volts times the current of one phase times power factor divided by 746. Using the same values as for the single-phase motor, the electrical horsepower input to the three-phase motor is $(1.732 \times 220 \times 50 \times 0.80) \div 746 = 20.2$ The foregoing is based on a single motor and the values obtained at the motor's switch.

Lost Motion in Valve Gear of Duplex Pump

Why are not the steam valves of a duplex pump firmly fixed to their stems, as they are in a slide-valve engine? W. F. S.

If there were no lost motion between the valves and the rocker arms and both rockers were direct rockers or both reversing rockers, the steam pistons would be driven to corresponding ends of their cylinders and stay there. This would be true because the sides would act like equal engines having the valves moved to their limit of motion in one direction without means for shifting the valves suitably for reversing the strokes of the pistons. If there were no lost motion and the valves were connected with rockers arranged in the usual manner, as shown in the figure, with one side called the leading side, with a long rocker arm connected by a direct-motion rocker arm *A* to the valve rod *V* of the following side, and the following side connected to the valve rod of the leading side by a reversing rocker *B*, any motion of the leading side would open the valve for the same direction of motion of the following side and the latter would simultaneously reverse the valve of the leading side and both sides would be brought to rest. If, before admission of steam, the pistons were moved to place the valves for admission of steam to either end of the following side, any movement of its pistons would result in movement of the valve of the leading side for motion in the opposite direction and carry with it immediate reversal of the following side, and the pump would be brought to rest the same as for first admitting steam for movement of the leading side.

When there is lost motion, each side is permitted to make part of a stroke before it picks up the valve of



DIRECT ROCKER ARM *A* AND REVERSING ROCKER ARM *B* IN STEAM VALVE GEAR OF DUPLEX PUMP

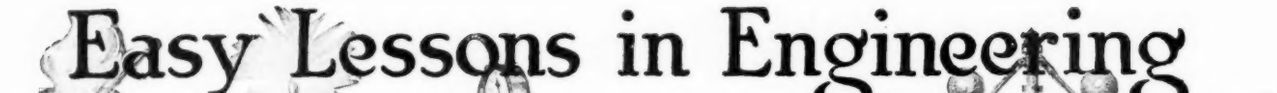
the other side, and by giving enough lost motion, each side may pause at the end of its stroke before it is reversed by action of the other side, thus giving time for the pump valves to become seated before the stroke is reversed. Or by making the last motion small enough, one side can be made to overcome the lost motion so early as to effect reversal without pause, or shorten the stroke of the other side.

Size of Steam Header for Battery of Boilers

What considerations should be taken into account for determining the size of the steam header for a battery of boilers? L. F. P.

The principal consideration is sufficiency of size to prevent material drop of pressure in the header below the boiler pressure. Some drop of pressure is inevitable, but intervention of the header should not cause more than 1 to 3 lb. per sq.in. drop of pressure below the boiler pressure at any point where branches are taken off and when the draft of steam is a maximum. Knowing the initial, or boiler pressure, maximum draft of steam and permissible drop of header pressure, the size of boiler connections and header can be estimated by formulas for computing the size of steam pipes. The pipe area thus obtained will not necessarily be equal to the combined areas of all branches, in fact usually will be smaller than the combined areas, since the size of each branch must be determined by itself, according to its length and permissible drop of pressure below the minimum header pressure, at the point of final delivery.

Easy Lessons in Engineering



Water in Motion

The easy lesson in the previous issue explained the laws of *hydrostatics* (water at rest). In a word the law is this: In water at rest the pressure acts equally in all directions and increases at the rate of 0.43 lb. per sq.in. for each foot of submergence, or one pound per square inch for each 2.3 ft., no matter what may be the shape or size of the containing vessel. The present article deals with water in motion, or *hydraulics*.

Under some circumstances the action of water in motion is much like that of a falling body. This can be seen from Fig. 1, which compares the velocity of a ball falling from rest with that at which water spouts from orifices at different levels below the free surface of water in a tank. If the water velocities are measured at the smallest diameter of the jet just beyond the orifice, they will be equal to the velocity of a bail

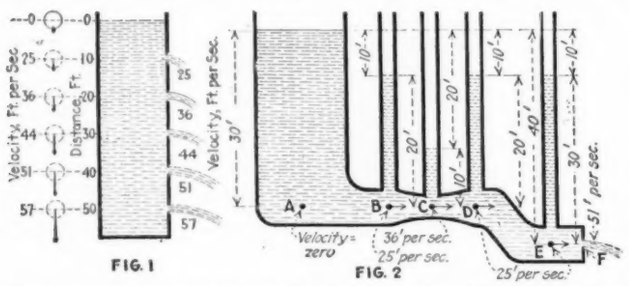


FIG. 1 FIG. 2

FIGS. 1 AND 2—FLOW OF WATER IN ORIFICES AND PIPES

that has fallen the same distance. In either case the velocity can be expressed by the formula $V = 8\sqrt{H}$ or *"The velocity in feet per second equals eight times the square root of the head in feet."*

By solving for H, the same formula can be written: $H = \frac{V^2}{64}$, or *"The head in feet equals the square of the velocity in feet per second divided by 64."*

Consider the case shown in Fig. 2, assuming that the pipe is frictionless and the entrance so smooth that there is no turbulence in the water; that is, that the water flows in perfect stream lines. Points *A*, *B*, *C* and *D* are all 30 ft. below the water level in the tank, while *E* and *F* are 40 ft. below. The area of the pipe is constant everywhere except at *C*, where it is $\frac{25}{36}$ of that elsewhere. Suppose that the orifice at *F* is so proportioned that the velocity at *B* is 25 ft. per sec. Then, since the same amount of water flows through all parts of the pipe, this must also be the velocity at *D* and *E*, where the diameter is the same. At *C*, due to the smaller area, the velocity will be $\frac{36}{25}$ as much, or 36 ft. per second.

Open water columns placed at various points as shown will measure the "pressure head." At *A*, where the water is practically at rest, the pressure head is 30 ft. At *B*, the column reads only 20 ft. The reason is that part of the original pressure head has turned into velocity head in getting the water in motion. Fig. 1 showed that 25 ft. per sec. velocity corresponds to 10 ft. head. So we say that the water at *B* has a "velocity head" of 10 ft. and a total head of $10 + 20 = 30$ ft., the same as at *A*. At *C* the increased velocity of 36 ft. per second gives a velocity head of 20 ft. The total head is 30 ft. as before, leaving a pressure head of only 10 ft. At *D*, where the velocity returns to 25 ft. per sec., the velocity head is 10 ft. and the pressure head 20 ft., as at *B*. At *E* the velocity head remains 10 ft., while the total head is now 40 ft., leaving a pressure head of 30 ft. In the orifice the pressure head entirely disappears; the jet spouts with a velocity of 51 ft. per sec., corresponding to the total head of 40 feet.

It should be remembered that this case is ideal. In an actual pipe the friction loss would cause a steady decrease in the total head.

This example illustrates the important law that the total head at any point is the sum of the velocity head and the pressure head. If the flow is horizontal and there is no friction, the total head does not change, which means that the pressure head must increase or decrease exactly enough to counterbalance the decrease or increase of the velocity head.

The sections *B*, *C* and *D* constitute a "venturi tube," which can be used as a meter to measure the flow of water if the areas at *B* and *C* are known and the difference in pressure between the two points is measured.

In actual cases of flow of water through pipes there is always some friction. This produces a continual drop in the total head. The total head at any point can be obtained by adding the pressure head and the velocity head. The gages or water columns used to measure the former must always be tapped off exactly at right angles to the direction of flow. If the flowing water strikes the opening, the shock will increase the reading. This fact is often taken advantage of to measure the velocity of water. Two tubes are inserted in the stream. The opening of one is square with the direction of flow, so this tube measures the pressure head only. The other faces straight upstream and gives a higher reading due to the impact of the moving water. The difference between the two readings is the velocity head and can be converted directly to velocity by the use of the formulas already given. Suppose the upstream tube gives the total head as 60 ft. of water, while the other shows the pressure head to be 40 ft. Then the velocity head is the difference, 20 ft., and the corresponding velocity is $8\sqrt{20} = 8 \times 4.47 = 35.8$ feet per second.

Heat Transfer for Water Flowing Inside Pipes*

W. H. McAdams and T. H. Frost

In all problems of heat transmission between water flowing inside pipes and any heating or cooling fluid outside, the heat flow is conditioned by three thermal resistances—that of the water film on the inner surface, that of the wall of the pipe, and that of the external fluid film. The first and the last of these are determined by a number of factors independent for each of the two films. The total or over-all thermal resistance is, therefore, a complex variable, difficult to analyze, whereas the individual resistances involved are relatively simple. As has long been suggested, it is highly desirable in engineering computations to use the individual film resistances rather than the over-all.

Equations for engineering use should have the broadest possible experimental basis. On this account the data available in the literature have been carefully studied and correlated by the method of dimensional analysis. The results are not entirely satisfactory, because few of the investigators have employed experimental methods above reproach. In most cases certain fundamental points have been overlooked. The only data collected under proper conditions are limited to one size of pipe and cover a rather narrow range. As a result of this study an equation has been developed for the coefficient of heat transfer between the water and the pipe in which it is flowing in turbulent motion. This formula is

$$h = \frac{138}{D^{0.2}} \left(\frac{u}{z_f}\right)^{0.8} \left(1 + \frac{50}{r}\right)$$

where

D = Inside diameter of the pipe expressed in inches;

h = Film coefficient of heat transfer, between the inner wall of the pipe and the main body of the water, the coefficient being expressed in B.t.u. per hr. per deg. F. per sq.ft. of inner wall;

r = Ratio of actual length of the pipe to its actual inside diameter, no units;

u = Average velocity of the water, in ft. per sec.;

z_f = Absolute viscosity of the water at the mean temperature of the *film*, z_f being expressed in Centipoises, as shown in Fig. 1. Note that z is the viscosity relative to water at 68 deg. F.

Where a liquid is in contact with a solid, there is strong evidence to show the presence of an adhering relatively stationary film of fluid on the surface of the solid. Through such a film heat can be transmitted by conduction only.

After the heat has penetrated the film, the hot molecules are picked up and carried away mechanically by the swirling motion of the main body of the fluid; that is, by the mechanism of convection. Hence the flow is controlled by the joint mechanism of conduction and convection. The data can be interpreted on the assumption that the sole resistance to heat flow between fluid and solid is found in the stationary film through which heat flows by conduction. Since it is usually impossible, and always inconvenient, to measure the thickness of this film, a "film coefficient" which in each particular case includes the definite, but unknown, thickness of the film, is used. As the convection currents in the main body of the fluid become more violent, it is obvious that the thickness of the stationary film will be decreased.

In cases met in practice the relative magnitudes of the resistances of the films and of the wall vary enormously. Furthermore, the value of each of the two film coefficients involved depends on a number of factors. The most logical method of predicting the value of the over-all coefficient for any case is, therefore, to estimate separately the value of each resistance for the conditions in question. This requires general equations for the film coefficient for three cases:

1. The transfer of latent heat from condensing vapors to a solid.

2. The transfer of latent heat from a solid to boiling liquids.

3. The transfer of sensible heat from fluids to solids, or vice versa.

The film coefficient for the transfer of sensible heat between solids and fluids depends on the same variables regardless of whether one is warming or cooling a liquid, a gas or a superheated vapor. However, in this paper the quantitative application of the relations to be developed was limited to water flowing in turbulent motion inside pipes.

The data at present available can be interpreted on the assumption that the sole resistance to heat flow between fluid and solid is that of the relatively stationary film through which heat is flowing by conduction. Since the specific thermal conductivity of the stagnant film can be determined experimentally, the problem reduces to determining what factors affect the thickness of the film.

Results of Experiments

In order to test these equations properly, one should have the results of carefully planned and conducted experiments on pipes of various diameters, in each case employing widely different ratios of length to inside diameter. In the case of each pipe runs should be made at constant water velocity, in order to determine the separate effect of viscosity. Also, water velocity should be varied over a large range. However, there are many pitfalls to be avoided and, unfortunately, some of these have been appreciated only within the last few years. For these reasons the data now available are not entirely satisfactory or are inadequate. This laboratory is now making additional experiments, but the results are not yet available. However, it is believed worth while to develop the most reliable equation possible from the data now available.

It is well recognized that when the velocity of the water is reduced to a certain value, the type of motion changes from turbulent or eddy flow to viscous or straight-line flow. In the latter case there is no mixing of the particles of water by convection and, hence, heat can flow by conduction only. Under such conditions it is obvious that the coefficient of heat transmission will depend only on the inside diameter of the pipe and the conductivity of the water, barring the effect of undue disturbance that may take place at entrance and exit.

In experimental work of this nature it is customary to calculate the amount of heat transferred per unit time by measuring the amount of cooling water in a given time and observing the rise in temperature. This gives the rate of heat transfer between the two sections at which the water temperatures were observed. As previously indicated, if film coefficients are to be observed, it is necessary to observe the temperature of the tube on the steam side. Since the temperature of the outer surface of the tube will vary along its length, owing to the rise in temperature of the water inside, one should observe the temperature of the outer surface of the tube at the same two boundary sections previously mentioned. This is conveniently done by attaching suitable thermocouples to the tube and calibrating them after the apparatus has been built. If these precautions have been observed, one can measure the temperature difference at each of the two sections of the apparatus, so that these temperature differences may then be averaged properly. In case it is desired to collect data on the steam side simultaneously, it is obvious that the devices used to measure the temperature of the steam should also be located at the same two boundary sections.

As previously indicated, in order to obtain precision in calculating the film coefficient on the water side, it is necessary to select a tube such that the drop in temperature through its wall will be small compared to the drop in temperature from the outer wall of the tube to the main body of the water inside. Of the commercial metals readily available, copper has the highest thermal conductivity. Furthermore, copper tubes may be obtained with very thin walls, and under such conditions the drop through the wall of the tube can be kept down to only a few degrees F., giving ample precision.

Obviously, when one is attempting to determine the effect of variables, such as water velocity, etc., the inner surface of the tubes should be kept clean.

*Abstract of paper presented at Nineteenth Annual Meeting of the American Society of Refrigerating Engineers, New York, N. Y., Dec. 4, 1923. Subject to revision by the authors and the Society.

The Value of Technological History*

By Loughnan St.L. Pendred, M.I.Mech.E.

Too often people twit those interested in the history of engineering about wasting time over musty records instead of spending it profitably on modern developments; they doubt the use of a society devoted to such work, the word "use" implying the use that brings money. That is not use but usury, and the work of the Newcomen Society cannot be put out to that employment.

Let us ask ourselves, in the first place: What are the objects and intentions of general history? Why has it been regarded for hundreds of years as an essential acquirement of the educated men? Why has it attracted the attention of great brains of all countries and in all times? Why do we accord to historians a position of exceptional honor? Can we show that general history has any practical, material, money-making value? I doubt it. To the statesman history is regarded as a tool. It is the yardstick by which he measures the events of his day. In it he finds warnings against error into which he may fall; in it he searches for examples on which to model his own actions. That is the theory. I am not sure that it is the practice. I am not sure that modern parliaments know much history beyond the faults and failings of the preceding government. The truth is that history does *not* repeat itself; the conditions that prevail at one time are never the same as those of a precedent time. The signposts of history point to roads long since closed.

The value of history is something different from usefulness. Harrison wrote: "We are so deeply indebted and so indissolubly bound to preceding ages, if all our hopes of the future depend on a sound understanding of the past, we cannot fancy our knowledge more important than the knowledge of the way in which this civilization has been built up." He meant that historical knowledge enables men to live fuller, more understanding lives.

I am prepared to give up any attempt to prove that historical research is useful in the same way that technological research is useful. But I am not prepared to say that it is therefore without value. On the contrary I am convinced that it has a higher value than technological research because it touches in us all something greater than our bodily comforts and amenities.

It is sometimes imagined that the purpose of history is to bring the past before the present. I conceive that it is no such poor peep-show business, and that history and archæology would never have won to that position which they hold in the esteem of intellectual men were there no more in them that that. The real importance of history resides, I venture to suggest to you, in its evolutionary characteristics. It is not merely a series of disconnected pictures of the past, but a complete and uninterrupted account of the development of human thought and feeling, of human institutions and human work.

Can we then say of technology that it has a connected history? If we can, then we have found a basis on the merit of which we may claim for that history a position beside all other great histories. We may claim for it on this ground alone that it is a proper study for intellectual men, that it will broaden our ideas and enlarge our minds; that it reflects one of the endeavors, probably the most important endeavor, of man from the beginning and is therefore a proper study for mankind.

"Exactly," says Mason in his "History of Invention," "as one sees in the natural world in geologic time plant and animal forms becoming more and more highly organized, so in the construction proceeding from men's minds and hands there has been a corresponding development, increased complexity and multiplied functions."

We must notice in this connection that all the elements of mechanical inventions were discovered years ago. How old is the crank, the reciprocating piston, the gear wheels, the cams and the links of all kinds that are pawns with which we work out new combinations? I cannot call to mind a single modern invention that has some wholly new mechanical device equivalent to the crank, the eccentric or a pair of toothed wheels, something of which the advancing shadow may not be seen in traditional usage or in the record of patents for mechanical inventions.

The theme to which our examination has now brought us is the influence of technology on human development. I am not aware that any historian has done justice to it. The contemporary bibliography of any subject in some measure reflects the amount of human interest that subject has aroused during a given period. It does not, indeed, give us quite what we want, but it does suggest one direction that organized investigation might take.

I have no doubt at all that every one of us gains some intangible good by the contact with his fellow members and that the papers presented to us do more than interest and entertain us for a passing hour. In the contemplation of the development of industries and inventions our judgment is taught restraint, our imaginations are enlivened and the moral influence that accompanies the doing of homage to those much greater than ourselves moves within us.

*Extract of address to the Newcomen Society Oct. 26, 1923.

Thermal Storage

The subject of storing heat is given a short mention in the memorandum by the chief engineer of the Manchester (England) Steam Users' Association. The question of heat, or rather, storage power, is of great importance. Ordinary lead storage batteries weigh about 150 lb. per hp.-hr. They will stand about 1,000 chargings. Nickel-iron storage batteries weigh 50 lb. per hp.-hr. They are said to have a long life. The efficiency of charging and discharging is about 60 to 70 per cent. Low-pressure steam receivers, which are sometimes used at colleries, taking up the winding-engine exhaust and delivering steam to auxiliary engine, working at about 30 lb. to 20 lb. pressure, would require steam vessels of about 500 cu.ft. capacity per horsepower-hour, and would weigh about 1 ton per horsepower-hour. Thermal storers, with about 110 tons of water, can store about 17,000 lb. of steam, which would be nearly equal to, say, 900 hp.-hr., so that the weight per horsepower-hour would be approximately 300 pounds.

It may be remarked that if the foundations of a steam receiver are strong enough, it may generally be advantageous to convert it into a water-type storer, provided the shell plates are sufficiently strong for the added water weight. Steam receivers are too bulky to be of use for large power storage, but the thermal storers proper are suitable for storing very large power.

For economical design a thermal storer should be spherical instead of cylindrical. Half-inch plates would be strong enough for a diameter of approximately 26 ft. The capacity of such a vessel would be twice that of the cylindrical one containing 220 tons of water, or 1,800 hp.-hr. The relative radiating surfaces, floor spaces and shell weights should be as four to five or per unit of power as against eight to five in the case of a cylindrical one, representing a saving of nearly 40 per cent. For most economical design a thermal storer should not be exactly spherical, but should have slightly smaller radius of curvature in the bottom half in order to compensate for the increased pressure per square inch due to the weight of the water.

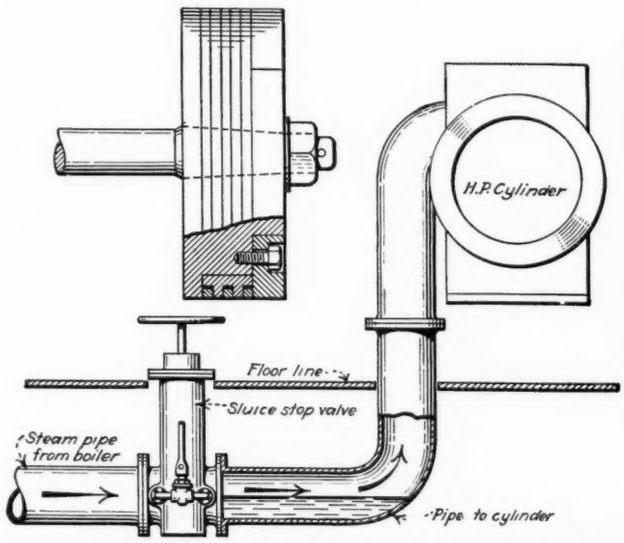
The *Mechanical World* states that "owing to the decrease in costs at the gold mines, the Victoria Falls and Transvaal Power Company contemplate building a new power station with a transmission line of 70 miles, involving a sum of over a million sterling. The site will be near Witbank Station, and the plant will consist of three generating units, each of over 20,000 hp. Contracts are being placed, and it is hoped that the station will be running early in 1925."

Strains and Stresses—A Correction: The third paragraph of the easy lesson entitled "Strains and Stresses" in the Nov. 13 issue refers to a "round rod one inch in diameter," whereas the drawings and calculations all deal with a half-inch rod. The sentence in the third paragraph should read: "This shows a round rod one-half inch in diameter . . ."

Water Causes Engine Breakdown

Water has at times produced trouble in steam engines and turbines. Failure to provide a drain for a water pocket in the header of a steam engine resulted in a wreck, as described in the October, 1923, issue of *Vulcan*, a magazine published by the Vulcan Boiler & General Insurance Co., Ltd., of Manchester, England.

It will be seen from the figure that when the engine is shut down there is an opportunity for water to collect be-



UNDRAINED WATER POCKET CAUSES ENGINE WRECK

tween the stop valve and the engine cylinder, owing to slight leakage in the valve.

This horizontal compound tandem engine, 26- and 50-in. diameters, 5½-ft. stroke, operating at 60 r.p.m., at 160 lb. steam, is rated at 1,220 hp. On starting up one Monday morning after draining the pipes in the customary way, the engine was turned over by means of a ¾-in. valve which bypassed the main stop valve. On opening the engine stop valve, there were two dull blows produced, whereupon the cylinder burst in two at the back end.

The explanation given was that, on opening the main valve, water was taken up with the steam, being injected on the forward stroke of the high-pressure cylinder. It is assumed there was sufficient lead in the steam valve to admit water at the end of the forward stroke. The first blow was caused by the water hammer in the forward end, where the water pressure against the piston rings pulled off the junk ring entirely.

The construction of the piston is shown in the illustration. On the return stroke pieces of metal and water caused the wreck of the main cylinder. Apparently, there is not direct evidence as to the absolute action of the water in causing the failure.

What Becomes of the Ash with Pulverized Coal?*

By H. D. Savage†

With regard to pulverized coal, the much discussed question is, "What Becomes of the Ash?" John Anderson (Lakeside Station, Milwaukee) says that he does not know—he never followed it up through the chimney. Personally, I have been too busy to attempt to follow it up, and as it has not seemed of particular interest to any of the neighbors of pulverized-fuel plants, either near or far, I can see no reason why a certain element who would not use powdered coal under any conditions, can so concern themselves with this discussion.

It is recognized and admitted today that every stack serving a steam station operating at any rating delivers a certain amount of débris to the surrounding atmosphere. It is quite true that in many cases means for eliminating the heaviest portion of this emission have been developed. There have been several ways suggested for eliminating or reducing the emission from a powdered-fuel stack should this ever become necessary, but to date no necessity has arisen for such installation.

The statement has been repeatedly made that from 40 to 70 per cent of the ash in a powdered-fuel installation goes to the atmosphere through the stack. This might be called a mythological fact—someone guessed at this way back in the dark ages. The only authentic data available covering the subject are from the carefully conducted tests made by the Bureau of Mines at Oneida Street. Taking 30 continuous tests under varying load conditions, they show an average of 29.5 per cent of the ash unaccounted for.

Just why the ash from powdered-coal installations is always referred to in percentage of ash, whereas in other tests it is referred to in percentages of coal fired, is not clear except, perhaps, because there is a considerable carbon content in the ash from other installations. Resolving 29 per cent of the ash from these tests back to the percentages of coal, the average ash in the coal being 11 per cent, this would make the stack emission from these tests, referred to percentage of coal fired, 3.1, which is about the same as with other methods.

Just what would this 29 per cent of the ash emission from a powdered fuel stack mean?

In order that we may bring this within our point of vision, we will assume conditions surrounding Hell Gate section if operating on pulverized fuel. We will assume that ten 15,000-sq.ft. boilers are operating at 200 per cent of rating continuously. This would mean a coal consumption of approximately 49 tons per hour, which, on the basis of 10 per cent ash in the coal, is equivalent to 117.6 tons of ash per 24 hours. If 29 per cent of this ash is emitted from the stack, it makes about 30 tons of ash in 24 hours.

We will assume a condition quite impossible, namely that all this ash would reach the ground within a radius of 1.5 miles of the plant, or an area of 7 square miles, which would contain 194,000,000 sq.ft., upon which this 60,000 lb. of ash would be deposited. If the ash were deposited evenly, which we admit would not be possible over this area, it would mean the distribution per square foot of the enormous sum of 0.00031 lb. per 24 hours, or the equivalent of 2.17 grains per 24 hours, or the sum of 1.8 oz. per square foot per year.

What is the character of this deposit? It will analyze approximately 80 per cent silica, 10 per cent alumina, some iron, lime, magnesia and no discoloring matter, so that we really deposit upon the earth, when it finally comes down, an earthy substance which contains no sooty or tarry matter, and the individual particles of which are so small as to be invisible.

If you will bear in mind that 65 per cent of the particles of the coal fired into the furnace were but 20 to 60 microns[1] in diameter, you must perceive that the resultant particles of ash are infinitesimal, and inasmuch as a study of these particles when isolated under an ultra-microscope reveals them to be never staple, it must be assumed that none but the heaviest of them ever fall to the earth until they are precipitated by moisture. This theory is borne out by the fact that, except in one instance, none of the very earnest investigators has ever been able to discover the resting place of any of the ash emitted from the stacks at either Milwaukee or Detroit.

Now we hope all of the foregoing discussion relating to ash has been entertaining, for we know it has been silly, but it is no sillier than the continued discussion by serious-minded engineers of this so-called ash problem, which is not today a problem in any plant now in operation, nor has it presented a problem at any time in the past.

*Abstract from paper delivered Nov. 27, 1923, at Toronto, before the Ontario section of the A.S.M.E.

†Manager of Pulverized Fuel Department, Combustion Engineering Corporation.

[1]A micron is one one-thousandth of a millimeter, so the particles mentioned range in diameter from one to three thousandths of an inch, approximately.—Editor.

News in the Field of Power

Hoover Tells Engineers About Waste in Labor Turn-Over

Advocates Co-operation, Synchronism, Higher Wages for Technical Staff and Standardization of Specifications

UNEMPLOYMENT during the periodic troughs in the business cycle is responsible for the greatest single waste. Troughs in the business cycle can be done away with if booms are eliminated. Accurate information as to stocks, consumption and distribution of commodities, made available at frequent intervals, will do much toward eliminating booms. These opinions were expressed by Commerce Secretary Hoover, in the course of remarks Dec. 5 at the annual dinner of the Washington Society of Engineers.

In the course of his remarks, which dealt largely with standardization and simplified practice, Secretary Hoover stated that one of the leading economic boards in the country had reached the conclusion that the exhaustive statistical service, represented by the business survey of the Bureau of the Census, and other figures compiled by the Department, had contributed more than any other single factor to the stabilization that has characterized business during the last twelve months. These figures permit the individual business man to interpret his own situation in relation to the country as a whole.

"Not much can be done to stabilize the bituminous coal industry until a solution can be found for irregular employment. That situation is one more likely to be solved by co-operation than by any corrective legislative.

"Lack of synchronism between industries leads to difficulties in transport. Industries must be in tune with each other. The public demand for coal happens to reach its peak just at the time of the crop movement. As a result, with only two exceptions in sixteen years, there always has been a car shortage in October and November. Car shortage causes great waste because it blocks distribution and influences the price levels of all commodities. By sheer propaganda, with the aid of good engineering, coal stocks were laid in earlier this year and the country has passed through October and November without the shortage of a single car.

"The matter of recruiting skill for the government's technical staff is a very serious problem. In three important technical bureaus, a recent analysis shows a turnover of from 30 to 40 per cent per annum. This would indicate to the average executive that his technical staff must be greatly underpaid. I know of no body of men as heroic as those in the scientific employ of the Government. The ability of these men and their technical accomplishments make them very attractive to private enterprise."

Secretary Hoover pointed out the advantages that would follow the publication of the Department's dictionary of specifications. This dictionary will be placed in the hands of 6,000 public purchasing agents, and will be a real contribution to the taxpayers of the entire country, he said. In the course of the work on this dictionary, a study of 1,200 articles showed some 24,000 specifications for them. By applying standardization to actual specifications, great savings will be made for the federal government.

Bureau of Standard's Budget Increased for Next Year

The budget, which has just been submitted to Congress, provides $130,000 to enable the Bureau of Standards to co-operate with government departments, engineers and manufacturers in the establishment of standards, methods of testing and inspection of instruments, equipment, tools, and electrical and mechanical devices used in the industries and by the government. This includes the practical specification for quality and performance of such devices and the formulation of methods of inspection, laboratory and service tests. This will permit of some expansion of this work. The amount appropriated for the current fiscal year was $100,000.

For the investigation of standards of practice and methods of measurements of public utilities, such as gas, electric light, electric power, water, telephone, central-station heating, and electric-railway service, and the solution of the problems which arise in connection with standards in such service, the budget carries $105,000. This is an increase of $10,000.

For technical investigations in co-operation with industries, upon fundamental problems involved in industrial development, with a view to assisting in the permanent establishment of new American industries, the budget carries $180,000. This is $30,000 more than was made available for use during the current fiscal year.

British Firm Gets Contract for Newfoundland Turbines

The Newfoundland Power & Pulp Co. has awarded the contract for the seven Francis type turbines of 14,000 hp. each, or 98,000 hp. total, to Armstrong-Whitworth & Co., Ltd., England. The company is building on the Humber River in Newfoundland.

New International Power Plant Equipment Firm Organized

The International Combustion Engineering Corp., of New York City, and Vickers, Ltd., of London, S. W. 1, have organized a corporation to be known as Vickers, Ltd., and International Combustion Engineering Corp., capitalized at £500,000 for the manufacture of power-plant equipment in England. It is the belief of George E. Larned, that this combination of American and British engineering and manufacturing ability will have a large influence on large power-plant practice in Great Britain and other parts of the world.

Gov. Smith Antagonistic to Superpower Plans

Further discussions of superpower plans for the Northeast are being delayed by the Governor of New York. It recently was proposed that the Governor of each state concerned designate a representative to make up a committee to enter upon a study of legal and other questions involved. Despite the fact that the committee's work is entirely one of investigation, intended to throw light on the situation, Governor Smith is understood to be antagonistic to the idea.

An essential to interconnection is that there be an absolutely free-flow of power across state boundaries. While the decision of the Supreme Court in the West Virginia natural gas case demonstrates that no direct barriers can be set up, it is recognized that the separate states must be in full sympathy with the plan, because otherwise indirect steps could be taken which would interfere with the plan being carried through.

A man should rub shoulders with the world for at least three years after his graduation from a technical school before an engineer's degree is conferred upon him, is the opinion of William Kelly, prominent Michigan engineer, and a director of and a nominee for the presidency of the American Institute of Mining and Metallurgical Engineers.

Output of Gas and Fuel Oil Increases During September

According to Bureau of Mines figures the gas and fuel-oil output in October was 1,069,800,191 gal., showing another slight increase of about 37,000,000 gal. over the September figure. Domestic demand increased about 92,000,000 gal., amounting to 1,015,725,028 gal. The total demand exceeded the new supply by about 45,000,000 gal., this amount being withdrawn from storage, leaving 1,436,591,014 gal. on hand at the end of the month.

Lubricants changed very little from September, production being 88,003,033 gal. and imports of negligible importance (2,017 gal.). Exports decreased about 6,000,000 gal. from the September figure, amounting in October to 25,590,031 gal., and domestic demand was 58,942,940 gal., also a slight decrease from the previous month. Stocks were increased by nearly 3,500,000 gal., there being on hand 218,485,258 gal. at the end of the month.

Conference on Public Works Called by the F.A.E.S.

As a part of the campaign for the reorganization of the Department of the Interior, the Federated American Engineering Societies has called a National Conference on Public Works to precede the annual meeting of the American Engineering Council during the week of January 7, 1924. The conference, which will occur on Wednesday, Jan. 9, in Washington, D. C,. will be attended by delegates from many national, state and local societies representing engineers, architects, constructors, manufacturers, chemists, geologists, economists, and business men.

The F. A. E. S. Committee on Procedure will meet on Jan. 7, the Executive Board on Jan. 8, and the American Engineering Council on Jan. 10 and 11. Among the important items of business will be the election of a successor to M. E. Cooley, who recently resigned the presidency of the Federation.

Italian Electric Production

Italy has central-station capacity of 1,582,528 kw., according to a report recently published by the hydro-graphic service of the Italian Ministry of Public Works. Of this total, 1,239,093 kw. are in hydro-electric plants. The output of energy produced by water power is almost four times as great as by other means, 74 per cent of the 481 plants in Italy being hydro-electric. The per capita consumption during 1921-22 was 85 kw.-hr., or 15½ kw.-hr. more than the average consumption for Europe, according to *Commerce Reports*.

Power Sites on Green River, Wyoming, Described

In the recent survey of the Green River, Wyoming, chief tributary of the Colorado River, made by R. R. Wooley for the Geological Survey, ten possible power sites are described, which range in capacity from 120 hp. with the natural flow of the river to 2,500 hp. with regulated stream flow. The investigation shows that nine glacial lakes on the west slope of Wind River Range near the Continental Divide might be utilized for the generating of power.

Nominating Committee Elected by A.S.M.E.

The Nominating Committee for next year as nominated by the local section delegates, and elected at the business meeting by the vote of the society, consists of: Group I—William R. Webster, Bridgeport, Conn., R. Sanford Riley, Worcester, Mass., Alternate; Group II—Kingsley L. Martin, New York, J. H. Lawrence, New York, Alternate; Group III—Charles Loeber, Richmond, Va., O. P. Hood, Washington, D. C., Alternate; Group IV—R. G. Nye, Buffalo, James Guthrie, Cleveland, Alternate; Group V — William M. White, Milwaukee, Harry S. Reid, Indianapolis, Alternate; Group VI—E. W. Burbank, Dallas, H. R. Auerswald, Oklahoma, Alternate; Group VII—Bruce Lloyd, San Francisco, Wynn Meredith, San Francisco, Alternate.

Production of Mexican crude oil reached the highest point during the winter of 1921-22, and has been gradually declining since January, 1922, although there was a temporary increase in May and June. The output for January, 1922, is officially reported as 20,641,828 bbls. and for December as 12,864,113 bbl. Total production for 1921 is given as 193,397,587 bbl. and for 1922 as 182,278,547 barrels. Exports for 1921 were reported as 172,000,000 bbl. and for 1922 as 180,000,000 bbl., and storage stocks in Mexico were approximately 30,000,000 bbl. on Jan. 1, 1922, and 20,000,000 bbl. a year later. The greatest decrease in production was in the fields back of Tuxpam, where the lighter and more expensive oils are found. some new wells are said to have been brought in farther north in

League of Nations Discusses International Problems of Water Power

The Questions Involved in the Development of Power on Boundary Rivers—Transmission of Electricity Between States and Compensations Considered

THE League of Nation's second general conference on communications and transit recently at Geneva discussed two draft conventions concerning electricity and water power of great importance from an international point of view.

Both these problems are practically new to international law, although there already exist a number of conventions as regards water power; for example, between France and Italy, or Canada and the United States, there are at present no precedents with regard to the transmission of electricity.

The Advisory and Technical Committee of the League, which drew up the proposed conventions, desired to avoid questions that might infringe upon the sovereignty of states. There are many points on which nations will have to show a conciliatory attitude, however, if the conventions are to be adopted.

Serious difficulties arose in connection with the draft convention on the development of rivers of international concern. The advisory committee endeavored to draw up a convention establishing the international law applicable to the entire basin of international watercourses from their sources to the sea. Difficulties caused by the shape and nature of various frontiers, as well as the constant danger of interfering with the sovereignty of states, makes it doubtful whether with the present knowledge, international law for watercourses can possibly be codified. It might be better for states through which a river runs, to agree among themselves to develop, by successive stages, the theories governing its exploitation. This procedure would still allow those states to have recourse to the League in case of dispute.

The outcome of the discussion is not yet known, according to the *Christian Service Monitor*, but it is very possible that the conference will prefer to postpone the drafting of these two conventions until more information is available and until national legislation in these matters has rendered international co-operation more simple to achieve.

Louisville Hydro-Electric Wins Preliminary Permit

A preliminary permit covering the development of power at the Falls of the Ohio River was issued Dec. 4 to the Louisville Hydroelectric Co. This action followed a decision of the Federal Power Commission denying a conflicting application from the City of Louisville. In line with that action the Commission also denied the application of the City of Louisville for preliminary permits covering proposed developments on the Cumberland and Green Rivers. The decision in this conflict has been withheld for a long period pending thorough consideration of the priorities which are to be allowed municipalities, under the Water Power Act, and whether or not municipalities are in a position to conduct the distribution and sale of power in areas outside of their jurisdiction.

the Panuco field, which produces the heavy oils. Considerable exploration and test drilling was done inland from the old locations and in the territory of the Isthmus of Tehuantepec, but results were not as successful as had been expected, according to supplement to *Commerce Reports*, 1922.

Flaming Gorge Project Still Hung Up

Notice has been served upon the Federal Power Commission that Wyoming would like to be heard before action is taken on the application of the Utah Power & Light Co. for a license covering its Flaming Gorge project. P. G. Hopkins, formerly an Assistant Secretary of the Interior, has been appointed Commissioner of Boundary Waters in Wyoming. He will have immediate jurisdiction over all matters where Wyoming is interested in interstate waters.

If the Flaming Gorge license is to be issued with a minimum of delay, it would be advisable for the power company and the state authorities to reach an agreement prior to a request that the commission grant the license. This issue does not concern a state in the upstream group and a state in the lower basin, as grouped in the Colorado River Compact, but involves two of the upstream states. Nevertheless it is anticipated that the Federal Power Commission would be inclined to withhold any action until the states concerned could reach an agreement.

Additions to the Program of the World Power Conference

Preparations for the World Power Conference are proceeding, and during the last few days several distinguished contributors on subjects of outstanding importance have been added to the program.

The Finnish government has appointed as its representative the engineer in charge of its water-power development, Hugo Malmi, who will present a paper on "Power Resources of Finland." Dr. C. H. Lander, of the fuel research board, will contribute a "National Survey"; Sir George Beilby, will present a "National Survey of Oil Resources." The "Winning and Utilization of Peat" will be dealt with by Prof. Pierce Purcell, of University College, Dublin. "Combustion of Powdered Coal in Cement Rotary Kilns," by Dr. G. Martin, of the British Portland Cement Research Association, will also be included on the program.

Canada is making preparations and has appointed a management committee with Dr. Charles Camsell, Deputy Minister of the Department of Mines, as chairman, and J. B. Challies, head of the federal water-power branch, as general secretary.

The two greatest buildings, the Palaces of Engineering and Industries, have already been handed over to the exhibition authorities.

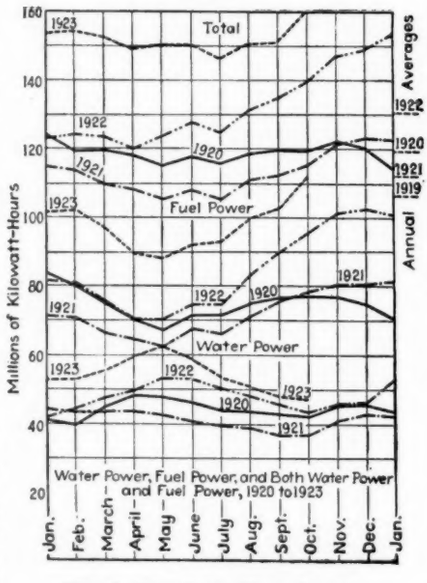
Two Water Power Projects for Shohola Creek

The Shohola Water Power Co., the Bingman Water Power Co. and the Blooming Grove Water Power Co. have declared their intention jointly to construct two projects on Shohola Creek, a tributary of the Delaware River.

The declarants propose to construct a 60-ft. dam at the head of Shohola Falls. They plan to run a pipe line from the dam so as to develop a head of 270 ft. at a power house in which two 4,000-hp. units are to be installed.

A second dam is to be 60 ft. high. This dam is to be constructed at Cold Springs Lake. A second pipe line will develop a head of 290 ft. In the second power house three 4,500-hp. units are to be installed.

The project will store two and one-half billion cu.ft. of water. It is probable that the Federal Power Commission will take jurisdiction over this project because that amount of storage would effect navigation on the Delaware River.



High Peak in Production of Electricity

The production of electricity by electric public-utility plants surpassed all previous records during the month of October with an average daily output of 160,400,000 kw.-hr., exceeding the previous maximum daily rate established in February of this year by 6,000,000 kw.-hr. The total output for October was nearly 5,000,000,000 kw.-hr. On account of the severe drought in the eastern part of the United States, steam power was forced to carry 70 per cent of this enormous load. To produce this electricity 9,928,414 tons of coal, 4,114,315 bbl. of fuel oil, 9,455,862,000 cu.ft. of natural gas was used and 32,748,000 kw.-hr. of electricity was produced by the use of wood as fuel; 4,525,966,000 kw.-hr. were produced by water power, 14,178,894,000 kw.-hr. by fuels.

Public Works May Be Division of Department of Interior

Prospects favor the success of the Brown plan for the reorganization of the administrative departments of the federal government in so far as concerns the setting up of a Division of Public Works in the Interior Department, and as it pertains to the Department of Commerce.

The main objection to the Division of Public Works comes from the Corps of Engineers of the Army. The plan will include, however, provisions to insure the assignment of engineer officers to river and harbor projects and other public construction.

The major changes in the Department of Commerce have been agreed upon unanimously. The President has authority in law to move the technical bureaus in that Department. The Attorney General now is considering if existing law does not authorize the transfer of all technical bureaus affected by the Brown plan by executive order. It is admitted, however, that legislation will be required to bring about the creation of the public works division of the Interior Department.

The remainder of the reorganization plan, it is believed, must await some new administration. If it can be accomplished within the first three months of an administration's course, before it has settled in its tracks, reorganization can proceed smoothly, it is believed.

The experience with the Veterans' Bureau has accentuated anew the desirability of placing all activities in a department. Within a department there is an esprit de corps which is a powerful check on abuses.

Committee on Muscle Shoals To be Negotiating Body

The President's proposal that a joint commission to consider offers for Muscle Shoals simply is an effort to set up an agency which has authority to negotiate. The regular committees of Congress are not organized with the idea of entering upon such activities.

It is known definitely that there are other bidders besides Henry Ford. This means that there must be intricate negotiations and thorough analyses of each bid. It is believed that the special joint committee idea provides the best means for determining which bid has the most value to the public.

It is understood that Mr. Ford is not worried because of the sale of the Gorgas steam plant. He does not seem to be greatly impressed with the need of duplicating that structure at some other point on the Warrior River. The assurance upon which he will insist is that right-of-way for a transmission line be guaranteed by the government. Under the right of eminent domain, no difficulty would be presented in furnishing such assurance.

Lease of Muscle Shoals to Henry

Ford with a provision that he manufacture fertilizer is provided for in a bill prepared for introduction by L. J. Dickinson, (R.), Representative from Iowa. The lease would be given under control of the Water Power Act at a nominal rental with a rebate on all power used in the manufacture of fertilizer.

John C. McKenzie (R.), Representative from Illinois, has filed a bill providing for the sale of the Muscle Shoals project to Henry Ford.

Huge Orders Placed in America by Japan

Orders aggregating $200,000,000 have been placed in this country by the Japanese since the earthquake. The great bulk of all orders placed by Japan has come to the United States. While a portion of this business reflects Japan's appreciation for the aid extended by this country at the time of the disaster, it is thought to have been influenced mainly by the willingness of American manufacturers to quote pre-disaster prices. In other countries bids reflected the sharp advance in materials which came with the anticipation of the Japanese demand.

Despite the large orders that have come to this country, it is recognized that no permanent value grows out of destruction. The effect of the Japanese earthquake will be felt over a long period in its having reduced the consuming power of the people of that Empire.

Cooperation Committee of Four Founders Societies Meet

An informal meeting of the Joint Committee on Co-operation of the Four Founder Societies was held in New York City on Dec. 10. This meeting was held for the purpose of discussing informally some of the common problems of the four Founder Societies.

By special invitation W. E. Wickenden, Director of the Board of Investigation and Co-ordination, Society for the Promotion of Engineering Education, explained the plan for the new investigation of engineering education to be conducted by the board with the co-operation of the four Founder Societies. It is hoped that there may be early participation in conducting the investigation.

Another problem under discussion, in which the four Founder Societies are much interested, was the development of an enlarged program for Engineering Foundation. It is expected that the exchange of views by the officers of the four Founder Societies will lead to unified action by the Boards of the Societies at their next meetings, to the end that there may be rapid progress on the part of this important agency for the furtherance of research.

At the informal meeting, the American Society of Civil Engineers was represented by President Charles F. Loweth and Secretary John H. Dunlap; the American Institute of Mining and Metallurgical Engineers by President E. P. Mathewson and Secretary F. F. Sharpless; the American Society of Mechanical Engineers by President F. R. Low and Secretary Calvin W. Rice, and the American Institute of Electrical Engineers by Past-President F. B. Jewett (representing President Ryan) and Secretary F. L. Hutchinson.

Program for Midwinter Meeting A.I.E.E. Announced

The program for the midwinter convention of the American Institute of Electrical Engineers, which is to be held at Philadelphia, Feb. 4-8, has been announced. The following papers and sessions will be of interest to power-plant men:

Monday afternoon—session on "Power Transmission." Wednesday morning—David Lindquist, Otis Elevator Co. "Transient Performance of Electric Elevators; E. M. Bouton, Westinghouse Electric & Manufacturing Co., "Variable Voltage Control Systems as Applied to Elevators"; A. L. Penniman, Jr., Consolidated Gas & Electric Co., Baltimore, "Power-Plant Auxiliaries and Their Relation to Heat Balance"; P. L. Alger, General Electric Co., "Shaft Currents in Electric Machines." Thursday morning—B. H. Smith, Westinghouse Electric & Manufacturing Co., and A. R. Rutter, "Recent Developments in Kilovolt-Ampere Metering"; B. H. Smith and R. T. Pierce, "Automatic Transmission of Power Readings"; C. M. Laffoon, Westinghouse Electric & Manufacturing Co., "Short-Circuits of Alternating-Current Generators."

The annual dance will be on Thursday evening, a visit to the Bethlehem Steel Company on Friday afternoon and an entertainment and visit to the Lehigh University on Friday evening.

Birmingham, Ala., will be the place of meeting for the Spring Convention of the Institute and the date April 7-11. An interesting program has been arranged which should attract electrical engineers from all over the country.

Obituary

Ralph E. Gilman, special engineer in charge of turbo-generator engineering of the Westinghouse Electric & Mfg. Co., died in the Methodist Hospital, Los Angeles, Dec. 5. Mr. Gilman, on account of illness, had been granted a leave of absence from his duties in East Pittsburgh, Pa., to go to the Coast in an effort to improve his health.

He was a graduate of the Leland Stanford University, of Palo Alto, Calif., receiving his E.E. degree in 1898. He entered the employ of the Westinghouse company immediately after his graduation and completed the apprentice course of the company in January, 1901. The next two years he was in the engineering department. In 1903 he was transferred to the British Westinghouse Co. and spent the next five years in London, England. In 1908 Mr. Gilman was recalled to East Pittsburgh and assigned to special duties in the power engineering department. He was in this department continuously until the time of his death.

Mr. Gilman is survived by his widow, Aimmie Gilman, of Palo Alto, California.

Water-Power Projects

Umatilla Rapids Project—To further plans for immediate commencement of work on the Umatilla Rapids Power Project, a meeting of the Umatilla Power Site Association was held in Pendleton, Ore., Oct. 29. The project would affect 270,000 acres and develop an estimated 800,000 horsepower.

New River Project—To the West Virginia Power Co., of Charleston, W. Va., a preliminary permit for two years for a power development on the New River from Narrows, Va., to Montgomery, W. Va., involving the construction of a dam approximately 750 ft. long on the crest and 140 ft. high, located about 5½ miles south of Hinton, W. Va., a power plant with an ultimate installed capacity of approximately 125 kw. and a 44,000-volt transmission line about 22 miles in length, extending from the power house to Beckley.

New Publications

National Electric Light Association. Proceedings of the 46th Convention held in New York City, June 4-8, 1923. Vols. 79-80. Published by the N.E.L.A., 29 West 39th St., New York City. Cloth; 8½x11¼ in. Price, $10.

Vol. 79 contains the "Proceedings of the General and Executive, Public Policy, Customer Ownership, Accounting Section and Commercial Section Session"; Vol. 80 contains the "Proceedings of the Technical Section Sessions."

The Prevention of Vibration and Noise. By Alec. B. Eason, M.A. (Cantab.), Assoc. M. Inst. C.E., A.M.I.E.E., author of "Flow and Measurement of Air and Gases." Published by Henry Frowde and Hodder and Stoughton, the Lancet Bldg., 1 Bedford St., Strand, W. C. 2, London, 1923. Cloth, 5½x8½ in.; 163 pages; numerous illustrations. Price, $3.50.

Containing only six chapters and two appendices, this book possesses the merit of being brief and directly to the point. On the other hand, it is evident that it represents an immense amount of work on the part of the author, and the benefit is passed on to the reader in several outstanding ways. In the front of the book appears a page giving the mathematical symbols used. There are seven pages of lists of scientific jour-

nals containing articles bearing on the subject of vibration. The reading matter is well analyzed in the table of contents, and indexes are included both of names and of subjects. The information was compiled by the author, who made a study of preventing vibration caused by unbalanced electrical machinery from becoming objectionable in buildings.

The first three chapters include a synopsis of problems investigated, the degree of vibration causing annoyance and instruments for measuring it, vibration in buildings, bridges, etc., and how this is transmitted. The remaining three chapters take up the subjects of isolating supports, and damping devices for vibration, the isolation of sounds, and descriptions of balancing machines. The subject matter is treated both from a practical and a mathematical point of view. Numerous illustrations, formulas and tabulations give an unusually complete exposition of the subject.

Elementary Steam Power Engineering. By Edgar MacNaughton, M. E., Professor of Mechanical Engineering, Tufts College. Published by John Wiley & Sons, Inc. Cloth; 6 x 9 in.; 571 pages; 463 illustrations. Price, $5.

The average student at the beginning of his junior year in college has but a faint idea of the equipment of the power plant. In many respects his steam-engineering knowledge is on a par with that of a Papin and Savery when they undertook to obtain power from steam three centuries ago. In the face of this lack of background on the part of the student, the majority of textbooks plunge immediately into the subject of power plant engineering. It is little wonder that the student wades through page after page of discussion concerning which he has but the faintest understanding. Professor MacNaughton evidently has discovered this limitation of the student, for he has so arranged the material in this volume that the entire philosophy of steam engineering is developed in a manner both logical and understandable. Since the volume is essentially a textbook, it will be of interest in the main to engineering students. The author is to be congratulated upon the thoroughness and simplicity of his treatment of the subject, covering, as he does, a concise description of the many machines and instruments found in power plants, together with a comprehensive discussion of the theory and operation of each machine.

Commerce Year Book, 1922; Including Early Part of 1923. Published by the Department of Commerce, Herbert Hoover, Secretary. Compiled under the direction of the Bureau of Foreign and Domestic Commerce, Julius Klein, director. Printed by and to be obtained from the Government Printing Office, Washington, D. C. Cloth, 6x9¼ in.; 692 pages. Price, 60 cents.

Early in his administration Secretary Hoover pledged himself to furnish additional facilities to American business to make possible, with less effort, the intelligent conduct of our trade. Another of these facilities is being made available this week in the form of the first "Commerce Year Book." It is a companion volume of the Department's "Statistical Abstract." It interprets figures, however, whereas the "Abstract" confines itself to basic data covering a wider range of detailed statistics than is attempted in this new authoritative review of the economic year. The book is in no sense a recital of the accomplishments of the Department of Commerce. It is a record, in the form of a compilation of data obtained by numerous agencies, specialists in their fields, of American industry put up in this form for ready reference.

Business is a great network of interrelated activities. The most effective conduct of any one of them requires a knowledge of trends in other trades. These are furnished in the "Year Book." The initial volume covers the calendar year of 1922 and the first half of 1923.

Coming Conventions

American Association for the Advancement of Science. Burton E. Livingston, Smithsonian Institution Bldg., Washington, D. C. Seventy-fifth anniversary meeting at University of Cincinnati, Cincinnati, Ohio, Dec. 27-Jan. 2.

American Engineering Council of the F.A.E.S. L. W. Wallace, 24 Jackson Place, Washington, D. C. Meeting at Washington, D. C., Jan. 10-11.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Midwinter convention at Philadelphia, Feb. 4-8.

American Institute of Mining and Metallurgical Engineers. F. F. Sharpless, 29 West 39th St., New York City. Annual meeting at New York City, Feb. 18-21.

American Society of Heating & Ventilating Engineers. C. W. Obert, 25 West 39th St., New York City. Annual meeting at New York City, Jan. 22-25.

American Society of Mechanical Engineers. Calvin W. Rice, 29 West 39th St., New York City. Spring meeting, at Cleveland, Ohio, May 19-22.

American Society of Safety Engineers. Genevieve S. Wood, 29 West 39th St., New York City. Annual meeting at New York City, Jan. 18.

Engineering Institute of Canada. Fraser S. Keith, 176 Mansfield St., Montreal, Canada. Annual General Meeting at Montreal, Quebec, Jan. 22—Ottawa, Ontario, Jan. 23-24.

Iowa Engineering Society. Blanche Veig, Acting Secretary, 406 Flynn Bldg., Des Moines, Iowa. Annual meeting at Cedar Rapids, Jan. 29-Feb. 1, 1924.

Master Boiler Makers Association. H. D. Vought, 26 Courtland St., New York City. Meeting at Chicago, May 20-23, 1924.

National District Heating Association. D. L. Gaskill, 112 West Fourth St., Greenville, Ohio. Annual convention at New York City, June 11-13, 1924.

National Marine Engineers' Beneficial Association. Geo. A. Grubb, 313 Machinists' Bldg., Washington, D. C. Annual Convention at Franklin Square Hotel, Washington, D. C. Jan. 21-26.

Society of Automotive Engineers. Coker F. Clarkson, 29 West 39th St., New York City. Annual meeting at General Motors Bldg., Detroit, Mich., Jan. 22-25.

Society of Industrial Engineers. George C. Dent, 608 South Dearborn St., Chicago, Ill. Eleventh annual convention at Buffalo, N. Y., April 30 to May 2, 1924.

L'Industrie du Gas by Réné Mase and Auguste Baril. Two volumes. Printed in French. Published by Gauthier Villars & Cie., 120 Boulevard St. Germain, Paris, France. Paper, 5½x7¾ in. Price, 20 francs each.

These two volumes, of which Vol. I, "Distillation of la Houille," contains 291 pages and 77 figures, and Vol II, "Traitement des Produits et Sous Produits," has 307 pages with 115 figures, belong to the Encyclopédie Léauté, second series. The first volume is on the modern processes of the gas industry; the second consideres the treatment of the products and byproducts.

Condensed Catalogue of Mechanical Equipment. Thirteenth Annual Edition, 1923-24. Published by the American Society of Mechanical Engineers, 29 West 39th St., New York City. Flexible binding; 8¾x11¼ in. Price, $5.

The 1923-24 edition of this valuable catalog is divided into sections in a way that makes it convenient for ready reference. The Catalog Section is divided into seven parts. Part 1 is devoted to "Power Plant Equipment" and contains over 200 pages; Part 2 to "Testing, Measuring and Recording Apparatus;" Part 3 to "Power Transmission Machinery;" Part 4 to "Conveying, Hoisting and Transporting Machinery;" Part 5 to "Metals, Alloys and Other Materials;" Part 6 to "Metal Working Machinery, Machine Tools and Shop Equipment"; Part 7 to "Compressors, Fans, Pumps, Heating Equipment, Hydraulics, Refrigerating and Industrial Machinery." The second section of the volume is also divided into parts; Part 1 is the "Mechanical Equipment Directory," Part 2, the "Consulting Engineers' Directory."

Annual Report of the Secretary of Commerce, 1923, Herbert Hoover, Secretary. Government Printing Office, Washington, D. C.

Smoke Abatement. By Osborn Monnett. Technical Paper No. 273, Bureau of Mines. Paper; 31 pages. Government Printing Office, Washington, D. C. Price, 15 cents.

History of Electric Light. By Henry Schroeder. Smithsonian Miscellaneous Collections, Vol. 76, No. 2. Published by the Smithsonian Institution, Washington, D. C.

Promoting American Machinery Sales Abroad. By W. H. Rastall. Trade Information Bulletin No. 138, Supplement to Commerce Reports, United States Dept. of Commerce. Government Printing Office, Washington, D. C. Free.

Society Affairs

The Cincinnati-Liberty Section No. 15, N.A.S.E., Cincinnati, Ohio, will have a discussion on "The Proper Education of an Engineer," at its Dec. 29 meeting.

The Vancouver, Wash., Section of the A.I.E.E. will hear M. L. Wade speak on the "Developments in Eastern British Columbia," at its Jan. 4 meeting.

The Meriden Section of the A.S.M.E. will hear A. E. Keating, of the American Tube and Stamping Co., Bridgeport, Conn., speak on "The Fuel Problem," at its Dec. 19 meeting.

The American Association for the Advancement of Science, at the Engineering Session on Dec. 28 will hear F. M. Feiker deliver an address on "The Place of the Engineer in Public Life."

The Boston Society of Civil Engineers will have "Hydro-Electric Development with Special Reference to the Hydraulic Equipment," as the subject of its Dec. 19 meeting. W. M. White, of the Allis-Chalmers Manufacturing Co., will be the speaker.

The St. Louis Section of the A.S.M.E., in its official publication, the *Forge*, has in the October issue tried out the convictions of one of its editors by printing this issue with white ink on black paper. Restful to the eye as it it, it is doubtful if it will be repeated on account of the practical difficulties inherent to the process.

Trade Catalogs

Burners, Oil — The Engineer Company, New York City. Catalog, "Oil Burning Under Steam Boilers," shows oil burners of several types and capacities using compressed air or steam, mechanical burners, oil sprays, air registers, balanced draft regulating systems and baffle walls.

Feeder, Boiler — Taber Pump Co., Buffalo, N. Y. Leaflet "Boiler Compound Feeder Helps Keep Scale Out of Boilers."

Valve—A. W. Cash Co., Box 135, Decatur, Ill. Leaflet describing six features of the reducing and regulating valve of this company.

Refrigerating Machine—York Manufacturing Co., York, Pa. Bulletin No. 70 describes with many illustrations these self-contained refrigerating units.

Heaters—Alberger Heater Co., Buffalo, N. Y. Catalog "Heater Data," contains much information concerning this equipment, arranged in convenient tables.

Fuels — Sanford Riley Stoker Co., Worcester, Mass. Bulletin No. 85, "Burning Waste Fuels," tells how to utilize various types of waste fuels in the Riley, Jones and Murphy stokers.

Heat Insulation — The Philip Carey Co., Lockland, Cincinnati, Ohio. Bulletin No. 101 describes Hi-Temp, a new high temperature insulation for use at temperature up to 1,000 deg. F. This bulletin should be useful to those interested in this subject.

Transmission — Colonial Supply Co., 217 Water St., Pittsburgh, Pa. "The Kite's Tail," is the name of the attractive little catalog issued by this company to tell about its products, ball bearings, transmission appliances, friction clutches, belting and other specialties.

Pulverizers—Fuller-Lehigh Co., Fullerton, Pa. Bulletin 900 "Pulverized Coal for Boilers," tells of pulverizers manufactured by this company and gives tabulations of tests of operating efficiencies, costs and also includes illustrations of the various types and installations.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Dec. 3, 1923	Dec. 10 1923
Pool 1	New York	$3.25	$3.25
Smokeless	Columbus	2.25	2.25
Clearfield	Boston	2.25	2.25
Somerset	Boston	2.50	2.50
Kanawha	Columbus	2.00	2.00
Hocking	Columbus	2.00	2.00
Pittsburgh No. 8	Cleveland	1.95	2.00
Franklin, Ill	Chicago	2.50	2.50
Central, Ill	Chicago	2.25	2.25
Ind. 4th Vein	Chicago	2.75	2.75
West Ky	Louisville	1.90	1.90
S. E. Ky	Louisville	2.00	2.00
Big Seam	Birmingham	2.15	2.15

New York—Dec. 13, light oil, tank car lots, 28@34 deg. Baumé, 3¾c. per gal., 36@40 deg. 4c. per gal., f.o.b. Bayonne, N. J.

St. Louis—Dec. 4, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.70 per bbl.; 26@28 deg., $1.75; 28@30 deg., $1.85; 32@36 deg., gas oil, $2@$2.05 per bbl.; 36@40 deg., distillate, 5¼@5½c. per gal.

Pittsburgh—Dec. 3 f.o.b. local refinery, 30@34 deg., fuel oil, 5¼c. per gal.; 36@40 deg., fuel oil, 5½c.; 34 deg., neutral 8c. per gal.

Dallas—Dec. 7, f.o.b. local refinery, 26@30 deg., $1.30 per bbl.

Cincinnati—Dec. 11, tank-car lots, f.o.b. local refinery, 26@30 deg. Baumé, 5c. per gal.; 30@32 deg., 5¼c.; 38@42 deg., distillate, 6½c. per gal.

Philadelphia—Dec. 7, 28@30 deg., $1.57½@1.62 7/10 per bbl.; 18@22 deg., $1.47@1.51 7/10; 13@16 deg., $1.36½@1.40 7/10 per bbl.

Chicago—Dec. 8, 24@26 deg., $1.62 per bbl.; gas oil, 32@36 deg., $1.97 per bbl.

Boston—Dec. 4, tank-car lots, f.o.b. heavy oil, 12@14 deg. Baumé, 4½c. per gal.; light oil, 28@32 deg. Baumé, 6½c. per gal.

New Plant Construction

PROPOSED WORK

Calif., Dixon—The East Dixon Irrigation Dist. had preliminary report prepared for the irrigation of 30,000 acres, installation of pumping plants, canals, etc., in Solano County near here. Estimated cost $1,000,000. F. C. Herrmann, Merchants Exch. Bldg., San Francisco, Consult. Engr.

Calif., Hanford—The Southern California Edison Co., 306 West 3rd St., Los Angeles, plans to build a substation on 5th St., here. Estimated cost $25,000.

Calif., Huntington Beach—The California-Pacific Textiles, Inc., c/o J. W. Purinton, 304 San Fernando Bldg., Los Angeles, is having preliminary plans prepared for the construction of a factory, including a 100 x 300 ft. main building, 4 story storage building, boiler house, shipping department building, transformer station, etc., here. Noted June 5.

Calif., Karlo — R. Krims, Yeon Bldg., Portland, Ore., representing a private mutual irrigation company, is having surveys made for the construction of works to irrigate about 8,000 acres, including dam, 33 ft. high, 2,800 ft. long on top, 1,200 ft. on bottom, 12 ft. wide top, slope on front 2½ to 1, earth and rock fill construction; 18,000 ft. canal, 18½ ft. wide, here. Cope, Means & Rand, 58 Sutter St., San Francisco, Consult. Engr.

Calif., Modesto—The Modesto Irrigation Dist., C. S. Abbott, Secy., will receive bids until Dec. 28 for furnishing and erecting twelve drainage pumping plants, each comprising a well, motor driven deep well turbine pump, motor started, also a sheet metal pumphouse.

Calif., Morgan Hill—The town trustees are receiving bids for a sewer system; water mains; treatment plant; pump house; two 4 in. pumps, 16 to 21 ft. head; two 5 hp. motors, etc. C. C. Kennedy, Call Bldg., San Francisco, Engr. Noted Oct. 30.

Calif., Oakland—The East Bay Water Co., 512 16th St., is having plans prepared for the construction of Upper San Leandro Creek Storage Reservoir and dam, 185 ft. high, 683 ft. long on crest, involving 1,200,000 cu.yd. hydraulic earth fill with storage capacity, 13,600,000,000 gal. Estimated cost $3,000,000. R. S. Hawley, Ch. Engr.

Calif., Ravendale—The Red Irrigation Dist. plans to vote $950,000 bonds for the irrigation of about 23,500 acres, including the construction of three new dams and enlargement of two existing dams; also about 50 mi. of canals. T. H. Means, 58 Sutter St., San Francisco, Consult. Engr.

Calif., Redwood City—The Pacific Gas & Electric Co., 445 Sutter St., San Francisco, is having plans prepared for rebuilding power lines and installing transformers to supply industrial plants east of here. Private plans.

Calif., San Francisco—The City and County of San Francisco, Bd. Public Wks., will receive bids until Jan. 9 for furnishing three butterfly valves, each 104 in. inside diameter; one c.i. blind flange for one side of valve; one steel platform extending over valves; all operating mechanism, bypass valves and connections; bolts and gaskets for joints, foundation and platform for Hetch Hetchy Moccasin Creek Power Plant in connection with penstock lines. Estimated cost $40,000. M. M. O'Shaughnessy Engr.

Conn., Thamesville (Norwich P. O.)—The Uncas Paper Board Co. plans to purchase a 300 kw. steam turbine.

Ill., Abingdon—The city is having plans prepared for a light plant. F. M. Connolly, 432 Peoples Trust Bldg., Galesburg, Engr.

Ia., Bedford—The city is having plans prepared for an electric light plant, including oil engine and dynamo, estimated cost $40,000; also distributing system, $25,000.

Prince-Nixon Eng. Co., 501 Peters Trust Bldg., Omaha, Neb., Engrs.

Ia., Sioux City—The Illinois Central R.R. Co., 135 East 11th Pl., Chicago, J. J. Bennett, Purch. Agt., is having plans prepared for shops, roundhouse and coaling equipment, here. Estimated cost $500,000. F. L. Thompson, Ch. Engr.

Kan., Fort Scott—The city plans to build an electric light and power plant. Estimated cost $200,000. Engineer not announced.

Kan., Olathe—The city is having preliminary plans prepared for the installation of a pump, pipe lines, etc. Estimated cost $25,000. E. T. Archer Eng. Co., 612 New England Bldg., Kansas City, Mo., Engrs.

La., New Orleans—The Administrators of the Charity Hospital, Tulane and Villere Sts., are having plans prepared for the first 5 story unit of hospital. Estimated cost $1,160,000, total estimated cost $3,750,000. Favrot & Livaudais, Hibernia Bldg., Archts. Equipment detail not reported.

Mass., Boston — The city, Dept. Public Wks., will receive bids until Jan. 12, for the construction of a 2 story, 200 x 200 ft. high school on Warren and Townsend Sts. Estimated cost $1,200,000. H. A. Atwood, Ashmont St., Roxbury (Boston P. O.), Archt. Other stories will be added later. Equipment detail not reported. Noted Nov. 6.

Mich., Detroit—The Peerless Portland Cement Co., 2408 1st Natl. Bank Bldg., is having plans prepared for the construction of a cement plant, capacity, 1,500 bbl. per day, on West Jefferson Ave. Estimated cost $1,500,000. A. Kahn, 1000 Marquette Bldg., Detroit, Archt. The owner is in the market for conveyors, elevators, etc.

Mich., Detroit—The University of Detroit, East Jefferson Ave., is having plans prepared for the construction of twelve 3 story buildings, including administration and general science buildings, gymnasium, power house, engineering building, library, chapel, etc., on Livernois Ave. and Six Mile Rd. Malcolmson & Higginbotham & Palmer, 1219 Griswold St., Detroit, Archts.

Mich., Pontiac.— VanLeyen, Schilling, Keough & Reynolds, Archts., 3440 Cass Ave., Detroit, are preparing plans for the construction of an 8 story, 80 x 150 ft. hotel, including steam heating equipment, boilers, etc., here. Estimated cost $1,000,000. Owner's name withheld.

Miss., Belzoni—The city, F. M. Pepper, Clk., will receive bids Jan. 10 for a concrete reservoir; concrete foundations for building and machinery; two 300 hp. water tube boilers; moving and resetting present 100 hp. H. S. G. boiler; coal conveying machinery; two 200 kw. turbines and generator; two 500 g.p.m. motor driven centrifugal pumps; one 500 g.p.m. synchronous motor driven pump; one 1,000 g.p.m. motor driven fire pump; one 1,000 g.p.m. steam fire pump; two turbine driven centrifugal boiler feed pumps; one steam boiler feed pump; steam and water pipe valves and fittings; two 350 to 400 brake H. P. full diesel oil engines with generators; one 8 panel switchboard; one building for either oil or steam plant. J. J. Sisloff, Supt. Water and Light Plant.

Mo., Hannibal—The city voted $400,000 bonds for pumps, motors, filtration plant, high service reservoir, mains, etc. D. H. Maury, 304 South Dearborn St., Chicago, Engr. Noted Nov. 13.

Mo., Moberly—The Polar Wave Ice & Fuel Co., 3628 Olive St., St. Louis, is having preliminary plans prepared for the construction of a 2 story, 100 x 200 ft. ice and storage plant, here. Estimated cost $150,000. H. G. Clymer, Wainwright Bldg., St. Louis, Archt.

Mo., St. Louis—The Bd. Educ., 911 Locust St., received low bids for the construction of a 3 story, 307 x 375 ft. high school on Natural Bridge Sts. as follows: general contract from the E. C. Gerhard Bldg. Co., Century Bldg., $1,240,000; heating and ventilating from the Soderman Heating & Power Co., 23rd and Morgan Sts., $156,447; boilers, Heine Boiler Co., 5319 Marcus St., $28,800; engine and generators, Chuse Engine Mfg. Co., Chemical Bldg., $21,660; vacuum cleaner, etc., J. Sheehan Plumbing Co., 1428 Olive St., $12,990; switchboard, Westinghouse Electric Co., 717 South 12th St., $5,000. Noted Nov. 13.

Mo., St. Louis—The Bd. of Public Service and Citizens Bond Issue Supervisory Com. approved $5,000,000 bonds, including $500,000 for the construction of a power plant.

N. J., Lakewood—The Genl. Eng. & Management Corp. is having plans prepared for a sewage treatment plant, consisting of clarification and sludge digestion tanks; pumping station, 2,000,000 g.p.d. capacity; Ingersoll Rand air compressors with air lift. Estimated cost $35,000. Remington & Vosbury, 601 Market St., Camden, Engrs.

N. J., Westmont—Haddon Twp. had plans prepared for sewers, sewage disposal plant, sludge pumping station, septic tank, sludge beds and on 4 in. diaphragm pump. Estimated cost $60,000. Remington & Vosbury, Courthouse Sq. Bldg., Camden, Engrs.

N. Y., Gouverneur—The city is having plans prepared for the construction of a 200 hp. power plant, dam, also installation of two 1,200 gal. centrifugal pumps and 100 hp. motor. Estimated cost $60,000. L. Reynolds, Geneva, Engr. Noted Nov. 6.

N. C., Old Fort—The Bancroft & Sons Co., Rockford St., Wilmington, Del., is having plans prepared for the construction of a large bleachery and factory town, including water and sewer systems, etc., here. Estimated cost $30,000,000. Q. E. Sirrine & Co., Greenville, S. C., Engrs.

Ohio, Cleveland—The city, c/o Comr. of Purchases, City Hall, is in the market for steam blower equipment for division of light and heat.

Ohio, Marietta—The City Council is having plans prepared for a water system, including automotive centrifugal motor driven pump, 20,000 gal. tank, fire hydrants, distribution systems with valves and fittings for Fairview Heights and Harmon Hill. Estimated cost $37,045.

Ohio, Toledo—The City Service Dir. received low bid for furnishing and installing a 35,000,000 g.p.d. 500 r.p.m. 78 ft. head, synchronous motor driven centrifugal pump with piping, valves and gages from Dravo-Doyle, Leader-News Bldg., Cleveland, $25,222. Noted Nov. 27.

Ohio, Toledo — The Libby-Owens Sheet Glass Co., Nichols Bldg., E. D. Libbey, Pres., will soon award the contract for the construction of a 1 story, 187 x 1,000 ft. plant along tracks of the New York Central R.R. Estimated cost $1,000,000. Devore & Co., 808 Nichols Bldg., Archts.

Okla., Carter—The town is having plans and surveys made for a waterworks system, including well, deep well pump, elevated tank and distribution fittings. Estimated cost $28,000. V. V. Long & Co., 1300 Colcord St., Oklahoma City.

Ore., Vernonia—The Oregon Amer. Lumber Co., 1017 Yeon Bldg., Portland, C. W. McGregor, Mgr., is in the market for boilers, engines, etc., for proposed sawmill, here.

Tenn., Union City — The city will soon receive bids for improvements to sewer system, water and electric light plants. Estimated cost $125,000. Noted Nov. 27.

Tex., Corsicana—The city is having plans prepared for the construction of a 30 x 60 ft. pumping plant with two 150 hp. Fairbanks-Morse centrifugal engines, etc. Estimated cost $15,000. W. W. McClendon, Engr.

Tex., Dallas—The Republic Natl. Bank, Republic Bank Bldg., had plans prepared and will receive bids early in January for the construction of a 20 story, 96 x 100 ft. bank and office building, including the installation of five elevators, on Main and Exchange Sts. Estimated cost $1,500,000. C. D. Hill & Co., Sumpter Bldg., Dallas, Archts. Noted Sept. 18.

Tex., Port Arthur—The city, J. P. Logan, Mayor, is having plans prepared for new pumping units for waterworks. Estimated cost $915,000. M. C. Erwin, Engr.

Tex., Raymondville—S. Butler, Kingsville, plans to build an ice plant and gin, here. Estimated cost $40,000. Engineer or architect not announced.

Va., Glen Lyn—The Appalachian Power Co., 31 Nassau St., New York, is having plans prepared for the construction of a power plant a.c. 60,000 kw. capacity here. Estimated cost $2,000,000. Viele, Blackwell & Buck, 49 Wall St., Archts.

Wash., Aberdeen—The city voted for the Wnyoochie power measure, providing for $2,000,000 hydro-electric development, 27,000 hp. If the cost totals more than $2,000,000 the project will be resubmitted to voters.

W. Va., Huntington—The Coal Exch. Bldg. Co., Inc., will soon receive bids for the construction of a 14 story, 60 x 170 ft. office building on 11th St. and 4th Ave. Estimated cost $1,000,000. Meanor & Handloser, Robson-Pritchard Bldg., Huntington, Archts. Equipment detail not reported. Noted Mar. 13.

Wis., Portage—The city, C. L. Loomis, Clk., is having plans prepared and will soon receive bids for a water purification plant, pumping station, etc. Estimated cost $100,000. Pearse, Greeley & Hansen, 39 West Adams St., Chicago, Engrs. Noted May 1.

Wis., Wisconsin Rapids—The city, Water & Light Comn., C. Gross, Chn., 344 2nd Ave., is receiving bids for a 100 g.p.m. centrifugal motor driven pump.

N. S., Yarmouth — The Yarmouth Cold Storage Co., Ltd., A. W. Eakins, c/o Parker-Eakins Co., Ltd., Purch. Agt., is in the market for complete equipment for new $75,000 cold storage plant.

Quebec—The Montreal Tramway Co., Craig St., W., Montreal, plans to develop 40,000 hp. at Carillon and 20,000 hp. at Riviere du Loup. Bids will probably be received in Jan., 1924.

Que., Chelsea — The Riordan Co., Ltd., 355 Beaver Hall Hill, Montreal, is having plans prepared for the construction of a power house and dam, here, also transmission lines to Hull and Ottawa, Ont. Estimated cost $1,500,000. Montreal Eng. Co., Ltd., 164 St. James St., Montreal, Engrs.

New Zealand, Wellington—The Public Wks. Tenders Bd. will receive bids until Apr. 30, 1924 (change of date) for Section 1, headworks of Arapuni Power Scheme. Noted May 29.

CONTRACTS AWARDED

Ark., Morrilton—The Arkansas Light & Power Co., Pine Bluff, will build a concrete coagulating basin with two gravity filters; well, including pumps and piping, here. Estimated cost $50,000.

Calif., San Francisco—The Pacific Gas & Electric Co., 445 Sutter St., awarded the contract for hydro-electric equipment, including turbines, valves, etc., about 100,000 hp. capacity, for Pit River Plant 3 to the Pelton Water Wheel Co., 19th and Harrison Sts., San Francisco.

Conn., East Hartford (Hartford P. O.)—The New York, New Haven & Hartford R.R., Grand Central Terminal, New York, awarded the contract for the construction of a boiler house and oil storage house, here, to the H. R. Kent Co., 5 Erie Ave., Rutherford, N. J. Estimated cost $45,000.

La., Welsh—The city awarded the contract for a 250 hp. vertical stationary heavy duty engine for electric light plant to The Busch-Sulzer Bros., Diesel Engine Co., South Broadway, St. Louis, Mo., $21,100. Noted Nov. 13.

Md., Amcelle (Cumberland P. O.)—The Amer. Cellulose & Chemical Co., 15 East 26th St., New York, awarded the contract for the construction of a plant consisting of nine units, here, to the Austin Co., Jefferson Bldg., Phila., Pa. Estimated cost $2,000,000. Noted Dec. 4.

N. Y., Binghamton—The Cutler Ice Co., 310 Front St., awarded the contract for the installation of an ice manufacturing system to the York Mfg. Co., York, Pa. Estimated cost $49,000. Noted Oct. 23.

Pa., Beaver Falls—The Duquesne Light Co., Chamber of Commerce Bldg., Pittsburgh, awarded the contract for the construction of a 2 story, 28 x 45 ft. substation on Water Alley, here, to the D. P. Robinson Co., 1300 Penn Ave., Pittsburgh. Estimated cost $100,000.

Pa., McKeesport — The Duquesne Light Co., Chamber of Commerce Bldg., Pittsburgh, awarded the contract for the construction of a 2 story, 40 x 68 ft. substation on 3rd Ave., to the D. P. Robinson Co., 1300 Penn Ave., Pittsburgh. Estimated cost $70,000.

Pa., Phila.—The Wilmington Bleachery Co., Market and Race Sts., Wilmington, Del., awarded the contract for the construction of a bleachery and a 30 x 40 ft. boiler house with Erie boilers to the Latta Armstrong Co., 1923 Sansom St., Phila. Estimated cost $125,000.

Pa., Pittsburgh—The Duquesne Light Co., Chamber of Commerce Bldg., awarded the contract for the construction of a 2 story, 74 x 109 ft. substation at 626 2nd Ave. and a 30 x 68 ft. substation on Winthrop St. to the D. P. Robinson Co., 1300 Penn Ave., Pittsburgh. Estimated cost $150,000 and $75,000 respectively.

Tex., Port Arthur—The Port Arthur Ice & Refrigerating Co. awarded the contract for the construction of an ice plant to the York Eng. & Supply Co., Texas Ave., Houston. Estimated cost $300,000. Noted Dec. 11.

Wis., La Crosse—The La Crosse Rubber Mills Co., Indian Hill, awarded the contract for the construction of a 4 story addition to factory and power house to the Holm-Page Co., Kishwaukee St., Rockford, Ill. Estimated cost $80,000. The owner is in the market for boilers, etc.

B. C., Esquimault — The Dominion Government, Ottawa, Ont., awarded the contract for centrifugal pumps, penstocks and sluice valves to Gwynnes Ltd., London, Eng., and C. Walmsley Co., Montreal, Que.; electric motors and switchboards to the Canadian Westinghouse Co., Peterboro, Ont.; nine electric capstans to the Vancouver Eng. Wks., 519 6th Ave., W., Vancouver, for the dry dock, here. Estimated cost $175,000.